Eng. lib.
C I
JUN 10 1924

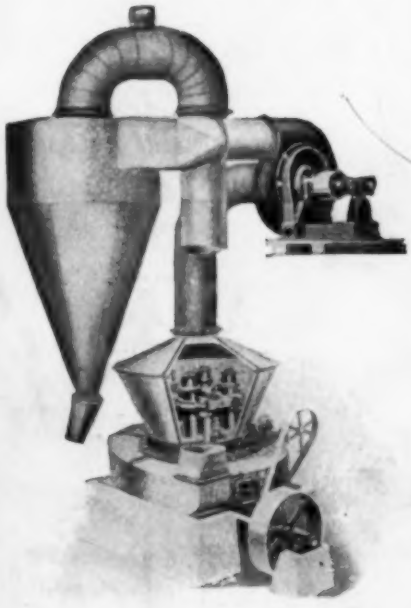
Metallurgical and Chemical Engineering

An Incorporation of

Electrochemical and Metallurgical Industry—Iron and Steel Magazine

Vol. XII. No. 1. New York, January, 1914. 25 cts. per Copy. $2.00 per Year to U. S. and Mexico. $2.50 per Year to other Countries.

In Plants Reducing Refractory Materials



the whole process of grinding and separating has a wide bearing, not alone on the cost of reduction but on the whole cost of plant operation. Also a most important effect on the quality of finished product and consequently on the market value of that product.

The installations of the

RAYMOND PULVERIZING-AIR SEPARATING SYSTEM

for the reduction and separation of all sorts of products have universally shown economies and efficiencies in excess of our definite guarantees.

These results have been accomplished by adaptability to the individual conditions of each case and have been produced largely **because** of that adaptability.

It is then manifest that you cannot fully appreciate what the Raymond System may do for you without a clear understanding of how it will apply **to your conditions.**

Our literature is, of course, at your service, but if you will ask us to show you how the Raymond System will produce value for you when adapted to your conditions you will secure a far better conception of what the Raymond System is and means, than you can ever obtain from printed descriptions.

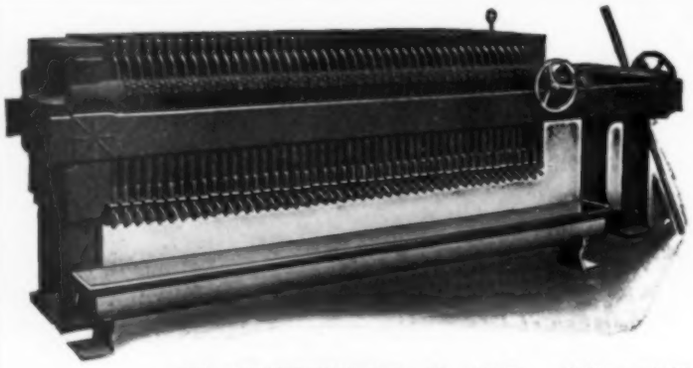
We are at your service.

Raymond Brothers Impact Pulverizer Co.

1305 No. Branch St., CHICAGO, ILL.

We design special machinery and methods for Pulverizing, Grinding, Separating and Conveying all powdered products. We manufacture Automatic Pulverizers, Roller Mills, Vacuum Air Separators, Crushers, Special Exhaust Fans and Dust Collectors

Ready Reference and Alphabetical Indices, pages 80 to 83



Long Life of Filter Cloths

is secured by widening the joint surfaces on the plates and frames of

Shriver Filter Presses

thus greatly reducing the chief maintenance expense. Some of their other advantages are the accurately machined castings, file-finished to within 4/1000 of an inch; interchangeable parts; counterbalanced thrust block, etc. *Prompt delivery is guaranteed* on the strength of our doubled facilities. All sizes and designs. Small laboratory presses. Write.

T. SHRIVER & CO., *Office and Works:* **808 Hamilton St., HARRISON, N. J.**

A NEW YEAR'S RESOLUTION

Increase Your Percentage of Perfect Castings
Reduce the Percentage of Defective Castings

We can help you to put such a resolution into effect by showing you where our carbon free ferro-titanium can be used to advantage in your iron or steel foundry.

If you have not yet tried this alloy you will be surprised to see the beneficial effects which it produces. Being free from carbon it is also free from injurious and insoluble carbides and slag.

Only a very small amount of this carbon free alloy need be added to the bath to obtain a marked purifying and deoxidizing effect.

The use of this alloy is an economical proposition from every point of view. On account of its purity the addition is small. As it contains about 6% aluminum it enables the user to eliminate the use of metallic aluminum as an addition to the bath and saves just that much expense. Most important of all, however, is the fact that it improves the **QUALITY OF ALL YOUR CASTINGS** and greatly reduces the percentage of defective castings.

It will pay you to investigate this alloy. Why not write now for our pamphlet No. 2041 which goes into the subject in detail? A copy will be mailed promptly on request.

GOLDSCHMIDT THERMIT CO.

WILLIAM C. CUNTZ, General Manager

90 WEST STREET, NEW YORK

329-333 Folsom St., San Francisco 103 Richmond St., W., Toronto, Ont.

7300 So. Chicago Ave., Chicago.

Chem. Engin.
Wilson
6-9-24
10293 (Vols. 12-29)

Metallurgical and Chemical Engineering

A Consolidation of Electrochemical and Metallurgical Industry and Iron and Steel Magazine

Vol. XII | New York, January, 1914 | No. 1

PUBLISHED MONTHLY BY THE

McGraw Publishing Company, Inc.

James H. McGraw, President.
C. E. Whittlesey, Secretary and Treasurer.
239 West 39th Street, New York.

Telephone Call, 4700 Bryant.
Cable Address, Metchem, New York.

Western Office.....421 Boston Bldg., Denver, Colo.
Chicago Office.....Old Colony Building
Philadelphia Office.....Real Estate Trust Building
London Office.....Hastings House, Norfolk St., Strand

E. F. Roeber, Ph.D., Editor.
H. C. Parmelee, Western Editor.

J. M. Muir, Manager.

Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50. (European exchange, 10 shillings, 10 marks, 12.50 francs.)

Copyright, 1913, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

New York, January, 1914

CONTENTS.

Editorial:
The Business Outlook..... 1
Progress in Copper Metallurgy..... 2
Progress in Gold and Silver Metallurgy, 1913..... 3
Developments in the Metallurgy of Zinc, 1913..... 4
Developments in Concentration Methods..... 5
Showing of the Iron Industry in 1913..... 6
Readers' Views and Comments:
Microstructure of Raw and Manufactured Copper. By Harry A. B. Motherwell..... 8
Hydrometallurgy—Joys of Its Theory, Woes of Its Practice. By Lewis B. Skinner and Warren F. Bleecker..... 8
Western Metallurgical Field..... 10
Iron and Steel Market..... 12
The Non-Ferrous Metal Market..... 13
Symposium of Paper on the Power Problem in the Electrolytic Deposition of Metals..... 13
Meeting of Secretaries of National Technical Societies..... 13
The Faraday Society..... 13
The Effect of Legislation Upon Chemical Industries. By T. B. Wagner..... 15
The Dunn Pulverized Coal Burner. By G. A. Roush..... 19
Concentration of Complex Sulphide Ores from the Mary Murphy Mine. By H. C. Parmelee..... 21
Chemistry of Salt Water Cement. By Harrison S. Taft..... 26
Color Photography Applied to the Demonstration of the Microstructure of Ores. By G. Rigg..... 30
Copper-Rich Kalchoids..... 30
A New High Temperature Furnace. By E. F. Northrup..... 31
Notes on Chemistry and Metallurgy in Great Britain..... 33
Utilization of Wood Waste; Bath Processes. By John E. Teeple. 35
International Electrical Congress..... 36
Ozonators. By A. Vosmaer..... 36
History of Electric Furnaces. By W. McA. Johnson and George N. Sieger..... 41
Handling Raw Materials at the Blast Furnace. By J. E. Johnson, Jr..... 44
Synopsis of Recent Chemical and Metallurgical Literature..... 53
New York Meeting of American Institute of Chemical Engineers with Abstracts of Papers by E. F. Lederle, E. A. LeSueur, E. J. Sweetland, E. A. LeSueur, A. Burger, A. Vosmaer, E. H. French and James R. Withrow..... 55
Analyses of Coals in the United States..... 62
A Large Electric Steel Furnace Installation..... 62
Recent Chemical and Metallurgical Patents..... 63
Oxy-Acetylene Welding and Cutting..... 64
Laboratory Mill..... 64
A New Electrolytic Process for the Production of Flat Perforated Copper Tubing for Radiators..... 65
Laboratory Vacuum Cleaning..... 68
Monel Metal..... 68
Personal..... 69
Digest of Electrochemical U. S. Patents..... 69
Book Reviews..... 70

The Business Outlook

There is a fortune in store for the inventor who can make a perfect looking glass. Most mirrors reflect the bleak and garish rays and make a person look worse than he really is.

A shrewd New England business man recently told us a story in point. He was feeling tired and nervous one day as he sat in a barber's chair—he could not get people to pay him what they owed him, the government were spoiling business, his workmen would not work, his lunch was not digesting, and it was raining outside. As the barber asked him whether he wished a tonic for his hair, he was shocked and grieved at the aged countenance reflected in the grim mirror. He looked at the barber's face in the glass. This fat and eupeptic representative of the race that conquered all Gaul and carried the victorious eagles to Ultima Thule, looked a sick, fat, flabby-faced, chicken-hearted degenerate son of the heroic masters of the world. Then he looked at the tonsorial artist directly. His poor weak brain could hardly believe his eyes. The barber he saw was really a well-nourished, charming man, who, with an education, might have served his adopted country well as a diplomat. The business man had the saving grace of a keen sense of his own limitations. He said to himself, said he: I am a poor mutt. The mirror is a darned poor mirror, and the mirror is a deus-ex-machina. At all events he quit worrying and sensibly went to work.

Now what is known as a business tone and financial sentiment has periods of distortion of view just as did this business man. Things are never as they seem, and things never seem as they are. Every perception contains truth and falsity. For instance, a year ago the metallurgical concerns of this country were running at full blast and prices of metal were high. Now the reverse is too true. People were then optimistic in the main. Now the reverse is true.

There have been many events that have tended to depress economic values—the Balkan war, the Mexican trouble, and in this country the long delay of tariff and currency legislation, and above all the poor corn crop of 1913. But if in holding the mirror up to industry we conclude that things are in a bad way, are we not making the same mistake as our business friend did? Let us ask ourselves how good are things.

About the only good thing we know of in industry is honest work and sincere intelligence. Intelligence is the faculty that gives us a knowledge of facts and tells how to foresee the coming of facts. While the unintelligent majority is wasting things, the intelligent minority is saving things. There are people in all classes, the aristocrats of democracy who make two

blades of grass grow where one grew before, who raise social values, who make life worth living. They are humble and proud, they are strong and weak, they are rich and poor, but they all put honest effort into their work, they understand the ethics of a good job, and they cheat neither society, their employer nor themselves. Their final and ultimate reward is a consciousness of duty well-done and a recognition by their compeers. Without this intellectually dominating minority this world would be a poor place.

Now, if not all signs of the times deceive us, it will be this type of man in all classes of human activity that will decisively shape the future. For ourselves in our limited field we may say that this journal will continue to strive its best to act as a clearing house of chemical and metallurgical ideas, of chemical and metallurgical facts, of chemical and metallurgical figures so that the efficiency of chemical and metallurgical operations may be increasingly higher. Efficiency is the keynote of the coming transition period in industry, and as it is eminently sane, we cannot help looking with hearty optimism into the future and thus we extend to our readers the compliments of the season.

Progress in Copper Metallurgy

As indicated in our previous annual reviews, the metallurgy of copper is now on such a basis that no striking innovations in smelting and allied processes have been made in recent years. In hydrometallurgy, however, the work of the past year leads us to suggest that we are on the eve of a remarkable development in this line. The success of experimental work already points to possibilities in reducing tailing losses and in making available vast quantities of copper-bearing material that hitherto have been untouched or regarded as waste.

In the preliminary preparation of copper ores by wet methods for concentration, the Hardinge conical mill, in an exhaustive test at Miami, proved itself superior to the Chilean mill in practically every particular and will be used generally in this class of work.

The handling of slime at Anaconda has been solved more satisfactorily than before, by means of Dorr thickeners and round tables. The round table is one of the oldest, but at the same time one of the most efficient machines for the concentration of extremely fine material. The objection to its use, however, has been its small capacity compared to the large amount of floor space required. A round table is usually from 20 to 30 ft. in diameter and has a capacity of about 6 tons of feed in 24 hours. By building tables with multiple decks, capacity per square foot of floor space is very greatly increased. Twenty-deck tables, with a daily capacity of 120 tons each are now in use, and tables with even 30 decks have been considered. Centrifugal concentration, which at one time appeared very promising, is abandoned temporarily at least, for these modified slime tables. Flotation methods, so generally used in the concentration of zinc ores, are slowly gaining ground for the treatment of copper ores.

The hydrometallurgical treatment of copper ores is rapidly advancing. About a dozen plants are now successfully treating copper ores or tailings by wet methods; and the number will almost certainly increase, for several companies are conducting experiments along this line. It is expected, for example, that an experimental plant for the treatment of copper slime by continuous counter-current decantation will be erected this year, making use of a principle which has been widely adopted in cyaniding slime. The mechanical thickeners for this plant will be constructed of acid-proof material.

The 80-ton hydrometallurgical plant of the Anaconda company is operating successfully and is the precursor of a much larger plant which will be erected to treat the daily tailing production as soon as a number of minor details are worked out in this commercial-experimental plant. The presence of silver renders necessary an oxidizing-chloridizing roast, and the results in silver and copper extraction and in cost of treatment have been very gratifying. Roasting is accomplished in modified MacDougal furnaces, having two fire boxes arranged so that their flames can be delivered to the third or fourth floor from the top. The third floor was finally adopted. The temperature is maintained at 1200° F. for oxidizing and at 1000° F. for chloridizing.

For complete roasting 3.56 per cent coal is required. Dust losses are small, ranging around 2 per cent. The recoverable percentages of silver and copper are 93.4 and 84.9, respectively. The cost for coal, acid and salt is estimated at $0.175, $0.096 and $0.07, respectively. The leaching solution contains 8 per cent. sulphuric acid and 10 per cent salt, and is used at a temperature of 85° C. The time required for extraction is about two and one-half hours. The total cost of treatment is estimated at 70 cents per ton, which makes the cost of producing copper from one-half per cent tailing seven cents per pound. The method of precipitating copper and silver from solution has not yet been finally adopted.

Two plants in Butte, the Butte & Duluth and the Bullwhacker, are operating on the oxidized surface ores of this district, using a sulphuric acid leach and electrolytic precipitation. The Butte & Duluth has recently changed its method of operation. Formerly the ore was crushed to ¼-in. mesh and leached in vats. Now, however, the ore is ground to about 8 or 10 mesh and slowly run through a series of very long Dorr classifiers, with counter-current washing in order to dissolve the copper and wash the solution from the ore. By this process the ore is exposed to acid for a shorter time, with less dissolution of such impurities as iron and aluminium, and with greater extraction of copper.

A modification of direct acid leaching is used at Braden, where a "neutralizing" leach with partly charged acid precedes the "acid" leach. Precipitation is electrolytic. At Chuquicamata the ore, mainly bronchantite, is leached with dilute sulphuric acid and the solution is electrolyzed. In this case the acid accumulates in solution by additions from the ore itself.

The Bradley process, which has been tried at Anaconda for the treatment of slime, has not yet proved a commercial success, and the plant has been closed for several months.

At Great Falls, as a result of some very careful ex-

perimental work, the capacity of MacDougal roasters has been increased from 46 to 77 tons cupreous material per day, the sulphur in the calcines being 7.9 per cent and 8.9 per cent, respectively. With the increase in capacity there has been an accompanying decrease in the labor required. A resume of results shows 270 and 180 furnace men employed, under the old and new practice, respectively. The average number of furnace men employed per 100 tons of cupreous material was 1.52 and 0.93, and of feeders 0.59 and 0.44, respectively, under the old and new practice.

The sintering of copper ores has not made the progress accomplished with lead ores, mainly because of the fact that the need for such treatment is not nearly so necessary. Some isolated cases of sintering and agglomerating with slag have been noticed, but the practice has not been generally adopted.

The development in converting copper matte has been not only in the continued use of basic linings, but also in the adoption of much larger converters than were in general use in past years. Converters of the upright-cylinder type, 20 ft. in diameter, are being very generally adopted and tonnages of many thousands on a single lining are the order of the day.

The dismissal of the famous Anaconda smoke suit by the Supreme Court is the final chapter in this prolonged fight and spells peace at least in Montana. In California the appointment of a commission to pass upon the many phases of the smoke situation will tend to bring order out of the chaos which has existed in that state for so many years. In Utah the situation is not very different from that of the past five or six years.

The invention of William A. Hall, by means of which the sulphur of ores may be saved in the elemental state, is an epoch-making one, and if the promise made by experimental work is fulfilled, when applied on a commercial scale, the smoke problem may be considered solved. This invention is the more meritorious in that it brings to light reactions which hitherto have been apparently overlooked. We may expect that sulphur, the material which has caused so much trouble in the past, will soon become, instead of a menace, an actual source of profit to the copper smelter.

Progress in Gold and Silver Metallurgy, 1913

Substantial improvement was made last year in methods of recovering gold and silver, but few striking innovations were brought forward. As has been the case in recent years, the cyanide process was the most important in point of quantity and value of metals recovered. Its use was extended to the treatment of a greater variety of ores; costs were reduced and extractions increased. Nothing of importance has occurred in the fields of amalgamation or smelting, and no data have been forthcoming from several attempts at chloridizing. The electro-cyanamide process, originally installed at the Ajax mill, Cripple Creek, was finally abandoned in favor of combined concentration and bromo-cyaniding.

A year ago we commented on the filter litigation and the successful defense of the Moore patents. At the same time we suggested that the end of the litigation was not yet in sight. The prediction was verified late in 1913, when Mr. Charles Butters filed a suit against the Golden Cycle Mining Company, Colorado, for damages for infringement of filter patents. This outcome was the more striking by reason of the fact that the Golden Cycle was one of the first to settle with the Moore company after the courts had sustained Moore's case against Butters. Mr. Butters has been active in other ways as well. In our department devoted to patents will be found a note on a new method of filter construction and operation, invented by Mr. Butters. His idea seems to be to avoid the Moore method of discharging the cake by a difference of pressure between the inside and outside of the filter leaf, and thus escape infringement of the Moore process. Another feature of the filter situation was the consolidation of the Oliver and Moore interests, possibly strengthening the position of both. On the other hand, the makers of the Portland filter, after investigating the whole matter of filter litigation, continued the manufacture and sale of their machines independently. While a number of large companies effected settlement with the Moore concern, many small users of vacuum filtration plants operated them without regard to the legal status of the business.

Consideration of the filter question naturally calls to mind the status of continuous counter-current decantation, as this process offers some measure of relief from the use of filters. Last year witnessed the greatest advances yet made in the use of this method of treating slime. Three companies abandoned filters in its favor: The Gold Road and Tom Reed, in Arizona, and the Lluvia de Oro, in Mexico; and a number of new plants adopted this method. The Gold Road company reports decreased loss both in dissolved and undissolved gold, partly due to further dissolution of metal in passing through the series of thickeners, although it was thought formerly that the plant had ample agitating capacity. Operating costs have been lowered. The quantity of cyanide used, covering both chemical consumption and mechanical loss, has been increased by not more than 1-10 pound per ton, although the ore is treated in a 2-pound solution.

At the Globe & Phoenix, Rhodesia, South Africa, a 350-ton continuous counter-current decantation plant was installed last year. Loss of dissolved gold in the tailing is reported to be only three cents per ton. A similar system was adopted by the Liberty Bell in Colorado, for the treatment of concentrates formerly sold to smelters. The new process affords a material saving to the company. In this case, in order to simplify treatment and reduce dissolved metal loss to a minimum, the tailings have been discharged into the regular mill circuit, ultimately passing out through the Moore filter. This gives the tailings additional agitation treatment and permits addition of all water at one place, *i. e.*, the filters. No additional labor has been required in the mill, and the total cyanide used is said not to be increased.

A late report from the Porcupine Crown mill, where the continuous counter-current decantation system was

adopted, states that an extraction of 96 per cent is being obtained. This result is interesting in view of the fact that concentration is not practiced in this mill as in some others in the same district.

The tall form of air agitator for slime, commonly known as the Pachuca, seems to have fallen in the estimation of American metallurgists, for most of the new installations have made use of combination air-mechanical agitators, such as the Dorr and Trent. The former, first described in our issue last January, has been adopted in new mills in Nevada, Colorado, Canada and Mexico, and some older forms of agitators have been displaced in old plants by it. Experience with this form of agitator indicates low cost for power, continuity of operation and high mechanical efficiency. Sand and concentrates are readily handled, and the treatment is adapted to the chemical requirements of the ore, thereby giving high efficiency in dissolution.

The use of aluminium as a precipitant of gold and silver from cyanide solution received increased attention last year. This method is not new, having been proposed and patented in 1893 by Carl Moldenhauer; but the idea was never developed on a practical scale. Various experimenters have tried Moldenhauer's scheme, but it was not successfully used until Kirkpatrick developed the application of aluminium dust in 1908.

Dissatisfaction with zinc precipitation at the Nipissing mill, led to the investigation of the merits of aluminium, with the result that it was finally adopted. A study of conditions at this plant showed that precipitated solutions had lost their normal dissolving power, and the cause was finally attributed to the presence of zinc and arsenic in solution. Since the adoption of aluminium, no further difficulty of this sort has been experienced.

There are a number of advantages in using aluminium for precipitation. Although it is more expensive than zinc, yet much less of it is used per ounce of metal precipitated. Aluminium does not combine with alkali cyanide as does zinc, hence does not cause consumption of cyanide. When the precious metals are precipitated, all of the cyanide combined with them is regenerated. This necessitates the presence of free caustic alkali in the solution. One of the obstacles to the successful use of aluminium dust has been the difficulty of wetting it and getting a thorough contact with the solution. This is overcome by the use of some form of vortex mixer.

Another new proposal in precipitation made last year was that of MacArthur, who suggested the use of zinc wafers or small sheets. He reported very satisfactory results to the Chemical, Metallurgical and Mining Society of South Africa, but subsequent investigators in different parts of the world were unable to confirm his figures.

The old scheme of volatilizing gold and silver from sulphide ores by roasting with salt was revived last year as a new invention in Australia. As pointed out in our columns at the time, the process of volatilization had been exploited in this country over ten years ago, but for various reasons was not successful. The Australian venture also is said to have been dropped.

The development of low-grade gold mines in Alaska has resulted in plans for milling on a huge scale. At the Alaska Gastineau the development has been so rapid that each succeeding report of progress has far outdone its predecessor in reporting available ore, and the tonnage now in sight is beyond mental conception. Prospective mill capacities also have increased by leaps and bounds, and following the last visit of the promoters to the property the prospective mill capacity jumped from 6000 to 20,000 tons per day. But with ore now said to run into the hundreds of millions of tons, the present operators can project mills of almost any old capacity without depriving their descendants of an opportunity to work the property and derive some of the enormous aggregate profit now in prospect. Actual milling operations will be awaited with interest.

Developments in the Metallurgy of Zinc in 1913

From a metallurgical point of view the status of spelter production was not materially changed during 1913. This is not to imply a dearth of experiment and research in the winning of zinc; on the contrary, there was marked activity in almost all branches of zinc-ore treatment. Some hopes have been realized, and progress has been recorded; but a reduction process has not been brought forth that can be considered a serious competitor of retort smelting.

In connection with retort smelting one item may be recorded which is of considerable advantage to the producer of zinc ore and concentrate. Hitherto the producers, particularly those whose output was small, have not benefited from any gold, silver, lead or copper which their products might contain, even though the gross value of these metals was substantial. In the case of large producers they might recover the retort residues and make a small profit by selling them to lead smelters, but such a procedure was out of the question for the small operator. More recently the zinc smelters have been offering contracts providing payment for gold, silver, lead and copper, in addition to the regular payment for zinc. The residues are then marketed by the zinc companies, and the small operator makes a profit without being put to the inconvenience of reselling small lots of residue.

This step on the part of the zinc smelters may be more or less of an experiment. Presumably it is not wholly philanthropic, and doubtless they anticipate a profit on the final transaction. The present forms of contract may be tentative, and the final form will depend on data accumulated from long experience; but the fact that other metals in zinc concentrates and ores are not to be a total loss to the producer is a matter for congratulation.

Electrolytic schemes for the reduction of zinc sulphate solution have been under close investigation during the past year. Metallurgically these processes look promising, but they seem to encounter serious economic obstacles. If we consider only the operating cost of production per pound of spelter, leaching and electrolytic reduction may show a margin of saving as com-

pared with retort smelting; but if interest on investment and amortization of plant be included, the margin fades. This is due to the comparatively enormous cost of an electrolytic plant as compared with a retort smelter of equal capacity.

The situation with regard to electrolytic reduction in this country might be relieved if we had enormous zinc-ore deposits, so that a large tonnage could be relied upon for a long period of time. A company owning such a deposit might then erect an electrolytic plant with assurance that its cost would be distributed over a large tonnage of ore, and that the ultimate cost of spelter would not be unduly affected. But, as pointed out editorially a year ago, there are not many such deposits in the United States; our supply of zinc-ore comes from many small mines. Probably the last word has not been spoken on electrolytic spelter, and such processes will be investigated in the future; but under present economic conditions they do not constitute a serious menace to the continuance of retort smelting.

No less interest attaches to the development of electric zinc smelting. Experimental work has been unremitting and the results are encouraging. This branch of zinc metallurgy holds out hope for the direct treatment of both simple and complex ores, eliminating the present costly and wasteful intermediate processes of concentration and separation. Another attractive feature is the possibility of a high recovery of the precious metals which, in the case of a complex ore, are now subject to loss in a succession of processes. Direct smelting with electric power is probably nearer realization than it was a year ago, and there is a possibility that the coming year will witness an attempt to put it in practical operation.

The advocates of hydrometallurgical methods also have been active during the past year, and their processes have attracted the attention of spelter producers and mine operators. It was expected that chloridization would be in active operation before the year closed, but that achievement has been delayed for one reason or another, and we will have to wait for definite results of this process. Another hydrometallurgical scheme involves a sulphatizing roast with subsequent extraction in water assisted by acid treatment. The ultimate product is zinc oxide.

No definite work has been done in this country during the last year in the recovery of zinc from lead blast-furnace slags. One proposal, patented last year, suggests the treatment of such slag with lime to displace the zinc oxide, collecting the latter as it is driven off at a high temperature. The process would be applicable to molten slag as it comes from the furnace, thereby conserving much heat. Pyrometallurgical concentration of low-grade zinc sulphides and carbonates, producing crude zinc oxide for reduction to spelter, has not made further progress in this country, although the idea has not been lost sight of. The success of the Pape process in Germany, both on old slags and on crude ore, has attracted a great deal of attention, and it is not unreasonable to assume that it will soon be tried in this country. The need for some such scheme is becoming more urgent in view of the increasing quantity of finely divided concentrate produced by flotation methods. This concentrate is not desirable material for retort smelting. If it can be briquetted and converted successively into oxide and spelter, a problem now confronting the zinc smelters will be solved.

On the whole a commendable lot of work has been done toward improving present processes and in attempts to develop new ones. A great deal of time and money have been spent in investigation, and there is apparent willingness to test new ideas of merit. Apparently no line of development has been finally dropped, and the coming year should witness a nearer approach to the realization of the hopes and ambitions of different investigators.

Developments in Concentration Methods

The record of ore concentration in the United States during 1913 is one of unusual interest. Technical literature has been replete with articles on research and practice, pointing the way to the solution of a number of problems and recording encouraging results from the treatment of ores that have been difficult to handle. Standard methods of concentration have held their own, but greater interest centers in the extension of accessory processes which must be credited with much of the improvement that has been shown in mineral recovery.

While a great deal of thought has been given to improved metallurgical efficiency, attention has been directed with increasing force to the economics of milling. Operators generally are realizing what the more thoughtful leaders have been emphasizing for some time, viz., that the highest metallurgical efficiency is not necessarily indicative of the most economic operation. In ore-dressing especially, commercial conditions must be kept in mind, and the requirements and preferences of the smelter must be considered. For obvious reasons smelter schedules favor the production of high-grade concentrates. Hence, one of the points the mill operator must keep in mind is the grade of his products. A high percentage of recovery in the form of a low-grade product may not be as profitable as high-grade concentrate representing a lower saving.

Perhaps the feature that looms largest in last year's record of concentration is the wider adoption of flotation, not only for zinc but also for copper ores. This process unquestionably has made a place for itself and is accepted as a valuable addition to ore-dressing. The Minerals Separation process is in operation at two places in Colorado; it is being tested on a large scale by the Inspiration Copper Company in Arizona, and in a smaller way at numerous places in the Western states. The Butte & Superior Company, Montana, is using flotation on a large scale, treating zinc ore. The Minerals Separation Company claims an infringement of its process in this instance, and has already won a suit for damages. Pending an appeal by the defendant, the process continues in operation under an order of the court which requires Butte & Superior to make a strict

accounting of all ore treated and concentrates produced by flotation. Regarding the outcome of this bit of litigation it would be hazardous to express an opinion, for past experience has shown that a legal opinion in such cases is not always consistent with sound technology. The result, however, undoubtedly will have a widespread effect on the future of flotation in this country.

In the mechanical concentration of slime no striking innovations have come forth. Multiple-deck tilting tables have found some advocates, and various forms of vanners have continued in favor. In a notable case, however, that of the Anaconda Copper Company, the buddle has found preference after a long campaign of costly experiment with various forms of slime concentrators. Twenty-deck buddles are a novelty, but they seem to be a rational development for the concentration of slime on a huge scale, and will be used at Anaconda this year. More extended reference to these machines will be found in our editorial review of copper metallurgy.

Another development at Anaconda, resulting from exhaustive tests, was the adoption of the Dorr continuous slime thickener for preparing suitable feed for the buddles. This device, well known in cyaniding, is finding extended use in concentration as a means of securing a feed of uniform consistency for flotation boxes and mechanical slime concentrators. The Anaconda installation consists of 40 four-deck Dorr thickeners, handling 20,000,000 gallons per day of water containing 2000 tons of slime. Other installations of thickeners in concentrating mills have been made by the Nevada Consolidated, Montezuma and Old Dominion copper companies. Scattered installations of these machines in flotation plants have proved valuable in preparing feed and in recovering water from tailings.

Dry concentration and separation has had an encouraging year. An elaborate testing and custom plant was erected in Denver by the Sutton, Steele & Steele Company for the demonstration of dry tables and dielectric separators. Many tests have been made and some custom work done on large lots. No new plants of this kind have been erected, but several are in prospect and may be built this year. One of the new machines brought out by this company, and now practically perfected, is an electrostatic table, being a reciprocating deck with an electrically charged surface over which the mineral particles progress by a series of jumps.

One of the most interesting and promising developments of the year was the Plumb pneumatic jig, described fully in our last issue. The features of this machine are simplicity of construction and operation, and perfect automatic control in discharge of concentrate and tailing. It offers an advantage in producing unusually high-grade concentrates, and has already attracted the favorable attention of some large operators. The coming year should witness its adoption in commercial work.

Electrostatic separation has been more widely adopted in the treatment of zinc-iron ores. Being a process of limited application, it is not in general use; but in those cases to which it is adapted, it is giving excellent results. The Huff machine has been greatly simplified in the manner of construction so that troubles incident to electrodes are believed to have been largely overcome. A good example of the conditions under which electrostatic separation is valuable will be found in the work at the Mary Murphy mill, described elsewhere in this issue.

In the preparation of ores for concentration, some new work has been done in sizing machines. Promoters of dry processes realize the necessity of reasonably close sizing, and have been trying to avoid the use of screens. Development work on the McKesson-Rice screenless sizer has been continued, and the Sutton, Steele & Steele Company has a new device for a similar purpose. Classification for wet ore-dressing has been improved and extended, although efforts are still being made to produce concentrators that will treat an unclassified feed. The new Isbell table is said to do such work with fair success. On the other hand, Prof. Robert H. Richards, always a strong advocate of classification, has recommended even greater refinements in the preparation of table feed; and, in a paper presented to the American Institute of Mining Engineers, has shown the probable benefits to be derived therefrom.

Showing of the Iron Industry in 1913

Market developments of the past year, studied in the retrospect, furnish ground for some interesting conclusions. Of greatest importance, perhaps, is the fact that while general trade activity began to decrease early in the year, it was not until the beginning of October that steel mills began to operate at much less than their full capacity. Several months before that decrease occurred the mills themselves had begun to look for a decided recession in demand and there is little doubt that the majority of producers were really surprised at the way material was taken in June, July, August, and September. The unexpected usually occurs in steel, and so it was that while one would normally expect an improvement in business in the early autumn it was just at that time that the real decrease in consumptive demand began to show itself.

Steel mill operations made a wonderfully good showing in the first nine months of 1913, viewed from the standpoint of business conditions generally, and this fact may indicate something. Upon analysis, it does not appear that in any specific direction there was a particularly heavy demand. There was no great rush of public or semi-public improvements. The railroads were moderate rather than heavy buyers. The steel flowed out through a multitude of channels. The consumption of steel has very greatly broadened in the past half dozen years, and this fact can be realized by recalling the nature of demand in 1906, which was a remarkably good year. Then there was extremely heavy buying by railroads; rail production reached a total which has not since been attained, even though the total production of steel has since greatly increased. The railroads were also heavy buyers of cars, locomotives and bridge material. Many large structures, office buildings, hotels

and bridges, were erected, consuming a larger percentage of the total output than is the case to-day. The tin plate production of the year, on the other hand, was 576,079 tons, whereas in 1912 and 1913 it has been about a million tons. There has been a correspondingly great increase in the production of sheets. The steel needed for the ordinary activities of the people has greatly increased, while there has not been as great an increase in the consumption of steel in the large channels, where financing is usually necessary. It has been relatively difficult to finance large projects in recent years.

These considerations furnish a basis for constructing a theory that the steel industry is undersized for the normal consumptive requirements of the country. It is not reasonable to conclude that the requirements of the ordinary people will not continue to increase, while it is hardly unfair to assume that a time is coming when large projects can be more readily financed. On any other basis it is difficult to explain why the steel industry reached a stage of full activity so readily in 1912, or why it continued its full activity so long in 1913.

A year ago, in reviewing the developments of 1912, the curious position of the merchant furnaces was referred to. It was pointed out that the year had brought an advance of about $4 a ton in pig iron, from a level which was absolutely profitless to the majority of merchant furnaces, but that three-fourths of the pig iron advance had been absorbed by advances in ore and coke, which many of the merchant furnaces must buy. The market did not seem to be giving the merchant furnaces their just due. It has all come out in the wash. There is too much merchant furnace capacity. A condition in general trade which easily gave full employment to the steel works, now supplied with pig iron almost wholly by their own blast furnaces, did not give full employment to the merchant furnaces. There has not been a sufficient increase in the pig iron requirements of foundries, malleable, gray iron and steel, to balance the increase in blast furnace capacity. Steel works have built furnaces so as to avoid buying merchant iron, and Lake Superior iron ore interests have built merchant furnaces so that they could consume their ore instead of selling it to merchant furnaces.

Largely as a result of this difference in alignment of the steel and merchant blast furnace industries to their respective markets, pig iron prices began to decline at the beginning of 1913, whereas steel products did not begin to decline measurably until August. Present pig iron prices represent a profitless level to a great many merchant producers, while the same statement cannot be made of steel products.

Despite the unfavorable trend of affairs, the year 1913 established new records throughout the iron and steel industry. Pig iron production amounted to about 31,100,000 tons, against 29,726,937 tons in 1912, which in its time was easily a record year. The production of steel ingots and castings was between 32,500,000 and 33,000,000 tons, against 31,251,303 tons in 1912. The production of rolled iron and steel was close to 26,000,000 tons, against 24,656,841 tons in 1912. Lake Superior iron ore shipments were about 49,750,000 tons, against 48,211,778 tons in 1912. The gains in production over 1912 were all effected in the first half of 1913; the second half developed production approximately at the average rate of 1912.

There is speculation as to the cause of the slump in demand which overtook the industry in the closing months of the year. Explanations drawn from recent precedents, 1907 and 1910, are quite insufficient, particularly if it be held that the present decreased demand is to continue as was the case after the recessions cited. In 1907 there was a financial panic, the unsoundness which thus culminated having been apparent for months in that no new projects of any magnitude were undertaken. Towards the close of that year practically all large work on hand was suddenly completed, bridges, buildings, railroad extensions, etc., whereas there has not been a great deal of large work in the past year, and much of the work that was in progress has not been completed. Two of the biggest jobs in steel ever undertaken, the Hell Gate bridge and approaches and the New York subway work, still involve years rather than months of work.

The decrease in demand in 1910, the latest precedent, was clearly seen later to have been due to the fact that the country stocked up with material, bought on the 1909 break in prices, the encouragement to stock up being furnished by the spectacular advance which occurred in steel prices during the second half of 1909. The stocks had to be liquidated, and the liquidation was not completed until 1911. In the past year there has been no similar stocking up; stocks are admittedly low everywhere.

Two hypotheses remain: that there is a period of decidedly bad business in store for industry in general, which would necessarily keep the steel industry from regaining a state of full operation; or that the present decreased demand for steel will prove only temporary.

The feeling so prevalent in many quarters that business is going to be bad for some time appears to come from psychological rather than physical causes. Many are disappointed that we have a Democratic administration, are disposed to be critical, and refuse to take anything on faith. But the tariff shows no signs of hurting the iron and steel industry, for October, the first month of the new tariff, showed absolutely negligible imports. The October trade balance in general, by the way, was spectacularly large, breaking all records for a month, and although not aided by harvest movement was at the rate of $1,670,000,000 a year, a rate of a billion dollars in excess of the best trade balance ever shown for a year.

If the present decreased demand for steel is only temporary, it can readily be explained. There is always, between buying movement in steel, a period of reaction during which prices fall, buyers restrict their purchases and reduce their stocks to the absolute minimum. Once it is established that a bottom has been reached, whether the period required be long or short, the market quickly revives.

Readers' Views and Comments

Microstructure of Raw and Manufactured Copper

To the Editor of Metallurgical & Chemical Engineering:

Sir:—In your November issue (p. 621) in the report of a meeting of the New York Section of the American Electrochemical Society reference is made to a paper on the "Microstructure of Raw and Manufactured Copper" by Mr. W. H. Bassett, Technical Superintendent and Metallurgist of the American Brass Company. A note is made of the structural changes in copper due to working.

Some six or seven years ago, whilst engaged in electrolytic refining of copper, occasion arose to discard several lengths of conductor bars. These had a sectional area of about 4 sq. in. The smiths on the plant could not work up or draw the old leads to make use of them for other purposes. These leads were all made on the works from electrolytic copper of 99.95 per cent copper content and having conductivity varying between 100 and 101 Matthiesen standard.

Little use was made of microphotographs at that date for determining impurities in metals. Through the medium of your columns I should like to ask if Mr. Bassett has ever applied microphotography to determine whether any structural change has taken place in a conductor carrying for a period of five years, a current such as is used in copper refining.

Can any one say why such copper bars could not be worked or drawn and had always to be sent to the refining furnace to be melted.

It would be of interest also to know if any change takes place after long use of conductors carrying high voltage currents from central power stations.

Gourock, Scotland. HARRY A. B. MOTHERWELL.

* * *

"Hydrometallurgy—Joys of Its Theory, Woes of Its Practice"

To the Editor of Metallurgical & Chemical Engineering:

Sir:—Referring to Mr. Malm's communication regarding chlorination of ores, I wish to mention some general points which occur to me. There is only a difference of opinion between Mr. Malm and myself as to whether this process will serve a useful purpose in producing metals cheaper than they are now produced in well-known and simple processes. All of Mr. Malm's figures for operations of this kind are based upon assumption.

Mr. Malm's process will serve a useful purpose, in my judgment, only on finely disseminated ores which are not mechanically separable. When he tries his scheme (demanding highly refined operative work) on a large daily tonnage scale, against good mechanical separation schemes, it is my opinion that he will not find the wide margin of profit he mentions in anticipation.

There are only a few mines producing complex ores of such a nature, or in such a finely disseminated state, that they cannot be separated with good milling practice. Separation processes are not usually applied at the best efficiency, because the miner, millman or mining engineer usually is not a first-class metallurgist. Consequently when one decries the failure of separation processes in such hands as these, he is not treating the possibilities fairly. And I venture to say that if some of the new complex, hydrometallurgical schemes were used by the average operator the results would be far inferior to those now obtained by mechanical processes.

There is no question in my mind that we are passing through a period of refinement in mechanical separation processes, and that these improvements will put such processes in the running with any complex chemical procedure that demands fine chemical balancing and control.

It is with regard to the comparative cost of old, proved processes, properly operated, and an estimate of the cost of his process that Mr. Malm and I cannot agree. For a long period of years it has been my privilege to compare anticipated costs with actual book costs in working chemical and metallurgical processes. One of the most difficult things that I have to contend with, and one that I find many others will not contend with, is to add enough to the proposed cost of a process to make the venture safe from a pocketbook point of view; and one of the most deplorable things is the attempted estimation of costs by persons who are inexperienced in such matters.

Just at the present time, for instance, an engineer of wide metallurgical training is working on an acid-leaching process, and has published figures on making sulphuric acid that are just about one-half what anyone else in the United States has been able to make it for; and, at that, under conditions of labor, supplies, etc., that are not as favorable as those existing at plants now in operation. I know how prone one is to under-estimate rather than over-estimate costs; and I know how process promoters err on this more than would an operating engineer.

I understand that Dr. Chauvenet's contention is that, no doubt, the costs of dry chlorination are underestimated at several points; and that, since financial profit determines the value of any process, the one in question is not considered good. In this connection I agree with Dr. Chauvenet and not with Mr. Malm.

Finally, I would like to refute the impression that has gone abroad that metallurgists engaged, for instance, in the zinc business, are asleep at the switch; that they are not competent to judge the value of various newly proposed schemes; that they want to stick to a cumbersome, annoying process rather than accept one that can be worked with regularity and ease. It is ridiculous to assume that our operating metallurgists are passing all the good things by.

Denver, Colo. LEWIS B. SKINNER.

* * *

To the Editor of Metallurgical & Chemical Engineering:

Sir:—My discussion of hydrometallurgy, in reply to Dr. Chauvenet's article, was not intended to embrace an adverse criticism of the Malm process. The presence of a single impurity ought not to be fatal to the operation of an otherwise successful process. Further, it was my understanding that the Malm process, although advertised for a number of years, had never been put into actual commercial operation. Mr. Malm has now specifically stated this to be a fact, thus giving sufficient authority for my statement that the theory is the best part of the process.

However, since Mr. Malm has frankly suggested that I am ignorant of the subject, simply because I mentioned it incidentally, and further since he insists upon a statement from me relative to his process, I am forced to proceed with a criticism of the Malm process in greater detail.

I wish to point out the following things: (1) My understanding of the theory of the Malm process; (2) the fact that the Malm process is inoperative; (3) that

the data given are incorrect and absurd; (4) my reference to the Malm process was justified by published facts.

Finally, Mr. Malm had knowledge of the paper and articles to be mentioned below, and if they were not in accordance with his results a public denial should have been made at the time. Further, the authorities quoted show such an intimate knowledge of the process, the equipment, the analyses, recovery and cost, that it is hard to believe that they were not inspired by Mr. Malm himself.

At a regular meeting of the Western Association of Technical Chemists and Metallurgists, held in Boulder, Colorado, January 4th, 1909, the Malm process was described by Dr. F. W. Traphagen, professor of metallurgy in the Colorado School of Mines.

The Malm process was specifically described in the Western Chemist and Metallurgist, in the May number, 1910, by Mr. Harry J. Wolf. The Malm process was again specifically described in the Western Chemist and Metallurgist, June, 1910, by Messrs. Jean McCallum and E. J. Bruderlin, of the Colorado School of Mines.

Details of this process after this time, so far as I have been able to ascertain, are meagre.

In case the process described in the references is not the Malm process, the matter is between Mr. Malm and the authors.

Quoting from Mr. Wolf: "In the Malm Process, or Western Metals Process, as it is sometimes called, the ore is suitably crushed, dried and subjected to the action of chlorine gas. The metals are converted into chlorides, which are dissolved and separated by methods of substitution. The zinc chloride is dissociated in an electrolytic cell of special design and the chlorine gas is recovered for reuse. The process is described more in detail as follows:"

Further: "The properly prepared ore is fed to a revolving tube of special design, in which it is subjected to the action of chlorine gas. The pulp is kept in contact with the gas long enough to chloridize 40 per cent to 70 per cent of its metal contents. The reaction between the gas and the sulphides is exothermic."

Further: "When the chloridization in the tube has been carried far enough to suit the requirements of the particular ore under treatment, the partially chloridized ore is passed from the tube into an agitator tank, where it is agitated in water or mill solutions, in the presence of free chlorine gas. Extraction is thereby completed and all the metal chlorides pass into solution."

A beautiful process of substitution is then described, the gold and silver being precipitated with metallic copper, the copper precipitated with metallic iron, the iron and manganese are reoxidized with chlorine gas and precipitated with zinc oxide, the calcium chloride is converted into calcium sulphate with zinc oxide in the presence of sulphur dioxide, and finally the solution is evaporated to dryness and the zinc recovered by fusion and electrolysis.

The molten zinc is recovered, and the chlorine is peacefully led back to the tube mill.

Thus we have a complete cycle of reactions which delight the soul of the professor and student alike. The chemistry is perfection itself; the chlorides without exception have a much higher heat of formation than the corresponding sulphide, and the substitution process dovetails like a set of child's blocks.

This is my understanding of the Malm process.

The Malm process will not decompose minerals other than sulphides, since the oxides, carbonates and silicates have higher heats of formation than the respective chlorides. Naturally some of the chlorine will in one way or another decompose a small quantity of water, forming hydrochloric acid, and some of the sulphur will be oxidized to sulphuric acid, but the action of these acids is not contemplated in the process as described.

Assuming that the most favorable conditions can be maintained, the extraction as claimed is difficult. Those who have worked with large quantities of chlorine gas and solutions containing chlorine will appreciate that the difficulties are almost insurmountable. There are but few containers adapted to mill work which will easily hold solutions strong in chlorine and at the same time permit the necessary agitation. Also one would not have an unlimited choice of filtering media. It is well enough to say that a filter press of suitable design may be used, but it is a more difficult thing to tell what the suitable material is. This applies to tanks and agitators as well.

The substitution reactions are not quantitative in a commercial way. It is always necessary to have an excess of precipitant in solution. For example, take barium sulphate, one of the most insoluble compounds met with in ordinary work. Try to precipitate all of the barium out of a solution with the theoretical quantity of sulphuric acid. It takes 24 hours for this reaction to take place completely, and then under favorable conditions of excess and temperature.

Assuming one has sufficient tank capacity to hold a thousand pounds of lead chloride in solution, the precipitation of the lead completely with metallic zinc will take time and more time. Also the zinc is going into solution at a very rapid rate, regardless of the lead.

Consider the laboratory precipitation of iron with zinc oxide. The conditions must be delicately adjusted, and a large excess of the precipitant must be added.

There is no magic in large operations which changes these things fundamentally. Time, concentration, heat, and equilibrium must be taken into account in the mill as well as in the laboratory.

Given unlimited time, unlimited apparatus, ideal materials, all of the reactions will take place, each in its turn and according to the chemical laws governing each case. It has yet to be demonstrated that the reactions as claimed will take place in an ordinary plant where operations are continuous and concurrent, where ordinary human beings are a function of operation, and where expensive and fragile apparatus must be used in handling large quantities of very low grade solutions and pulps.

The mainspring of the entire system, the electrolytic decomposition of zinc chloride is in itself a delicate operation. If the production of zinc were as easy as one might be led to believe from a description of this process, no other known process for the recovery of this unhappy element could compete with the electrolytic process. The ease with which zinc is obtained in the Malm process will be referred to later.

I probably shall not convince Mr. Malm that the process is inoperative, but I have stated my reasons specifically above.

To quote further from Mr. Wolf: "From 60 to 70 per cent of the cost of operating this process is for electric power. Direct current at relatively low pressure is used for the electrolytic work. The consumption of power varies with the metal contents of the ore. In practice an actual recovery has been made of 14.2 to 14.4 pounds of zinc per horse-power day."

The theoretical quantity of zinc deposited per horse-power day at 3.5 volts (the voltage specifically stated) is:

$$\frac{746 \times 24 \times 3600 \times 32.7}{3.5 \times 96{,}540 \times 453.5} = 13.8$$

The electrical efficiency of the process is therefore $\frac{14.3}{13.8} = 103.5$ per cent.

The heat required for the operation is doubtless derived from the calcium sulphate.

The recovery is stated to be as follows:

Gold	90 %
Silver	91.6%
Lead	97.4%
Copper	99.3%
Zinc	94.2%

The value of the above products taken from one ton of ore is said to be $23.58. The total cost, including mining, freight, selling and overhead charges, as well as a royalty of 85 cents per ton, is given as $13.57, of which the "entire cost of treatment" per ton is $5.32.

On the average, 65 per cent of this $5.32 was for current; or the entire cost of grinding, chloridizing, decanting, heating, filtering, drying and bottling was $1.86 per ton.

It will be noted that for every pound of metal recovered, at least one pound of zinc must be plated out. To be conservative one should say a pound and a half of zinc to allow for an excess of the precipitant in each case. If this is true (it is an assumption on my part, and not a statement of the writers referred to) we see 414 pounds of zinc recovered per ton of ore treated at a cost for electrical energy of $3.46. One may be sure that there is no half-cent-per-kilowatt-hour rate in Colorado. It is nearer two cents.

This freak list is not complete without the analysis of the ore. The crude ore assayed as follows:

Gold	0.18 oz. per ton
Silver	13.97 " " "
Lead	4.78%
Copper	0.68%
Zinc	9.00%

It is a remarkable ore which can be obtained for treatment in quantities of 15 tons per day and contains no silica, lime, iron, magnesia or arsenic. These should have been mentioned, since every pound of iron and lime which are chloridized must be disposed of at a heavy expense of zinc.

It is stated that the average profit per ton was $10.00. This means nothing short of $150 per day, or $45,000 per year of 300 days. This is 10 per cent net income or close to half a million dollars. Half a million dollars would put up a fair-sized plant, so Mr. Malm has only himself to blame if he is still unable to complete his Georgetown mill.

Therefore I am convinced that the statements in the references are both incorrect and absurd.

As to the calcium sulphate proposition, it was stated at the meeting above mentioned that the calcium sulphate was causing considerable difficulty. It is stated in one of the articles that calcium sulphate is precipitated by zinc oxide and sulphur dioxide. It is a matter of common knowledge that mill solutions retain relatively large quantities of calcium sulphate, and upon evaporating these solutions the material will certainly appear in the residue.

It now appears that Mr. Malm has either greatly modified his process or developed an entirely new one. Of this I freely confess to know but little. It is to be hoped that this new process will come from under cover so that it may be intelligently discussed, if Mr. Malm desires such a procedure. I do not believe there is a metallurgist in the world who would not be pleased at the ultimate success of the dry chlorination project; and Mr. Malm is deserving of great praise, and substantial reward, should he succeed in making his dream come true. The problems to be solved are as numerous as they are formidable. That many of them have been overcome I believe.

Until such a time as Mr. Malm gives us an equally detailed statement of his present process his previous utterances should stand, and we must base our opinions upon the information he has given us. It remains for Mr. Malm to state specifically and sincerely how he can recover the values from complex Colorado ores at the exceptionally low figure of two and one-half cents per pound.

WARREN F. BLEECKER.

Canonsburg, Pa.

The Western Metallurgical Field

Gold Mining and Milling in Georgia

Those who have investigated the history of gold mining in America are inclined to believe that the origin of the industry can be traced to early discoveries and operations in the southern Appalachians. In any event, gold has been produced in Georgia since 1829, for which year the output was officially noticed in the U. S. Mint returns. In 1838 the government opened a mint at Dahlonega and continued coinage there until 1861. This mint coined over $6,000,000 in gold.

At the December meeting of the Colorado Scientific Society, Mr. A. J. Hoskin presented the results of his experience with gold mining and milling in Georgia, giving many details of historical discoveries and early operations, and reviewing the present status of the industry. The rock formations containing the valuable ore deposits are all metamorphosed. The original sedimentaries were chiefly sandstones and slates; but oxidation has been constant, and the original rocks have decomposed in place, giving rise to a condition peculiar to this region, and affecting the methods of mining and milling. The term "saprolite" (rotten rock) has been coined to describe the ore. It is soft and friable, and disintegrates readily in water.

The fineness or purity of Georgia gold is very high, varying from 950 to 980, being wholly free from copper and alloyed with silver only. In size the gold ranges from dust to large nuggets. The small particles of gold are difficult to recover in milling, as they do not readily amalagamate. Some of the difficulty in amalgamation is attributed to nature of the gangue rather than to the quality of the metal.

The mining methods adopted are peculiar to the region, and consist generally in hydraulicking or in dry pick-and-shovel work with subsequent sluicing of the loosened mass from the open cut. The milling process would be deemed inefficient in comparison with practice in the West. Too many opportunities exist for loss of gold. The first part of the process consists in what is known locally as "reducing," meaning thereby a decrease or reduction in the bulk of the ore sent to the mill. This is accomplished by sluicing the ore from the open cut to the mill. During its travel through the sluice the ore is disintegrated, so that on arriving at the stamp mill much of the material will pass a screen of ½-in. or ¼-in. mesh. The Georgian miner assumes that only the coarse portion is worth treatment by amalgamation in the mill, for the gold in the disintegrated portion is supposed to have been recovered in the sluice. Hence the portion passing the screen is run to waste. It would seem almost certain that much gold must be lost in the fine particles that pass the screen, but such is the custom of the local miner; he recovers some gold in sluices, being that part of the metal which has been liberated by the disintegration of the ore, and then treats the coarse ore by stamp-amalgamation to make an additional recovery.

The stamp mills have been evolved to suit local conditions. The stamps are light, weighing from 300 to 450 pounds each. They are run with a low drop, about 95 per minute, and are fed by hand. The plates are silvered copper, but owing to the poor treatment given the plates by the millmen the results are not all that

could be desired. The plates are kept too hard or dry, and the millman apparently is averse to using enough mercury to give a proper surface for good amalgamation. This makes cleaning-up a difficult matter, and consequently leads to another bad practice, viz., the use of sharp putty knives in scraping the plates. Knives have always been used to detach the dense deposits from the plates—a practice which might be tolerated with cheap copper plates, but which is prohibitive with expensive silvered plates.

Sulphide ores are found in Georgia, but the miner has a strong aversion to them on account of the fact that they blacken the plates. Mr. Hoskin found that the cause of this lies in the extreme acidity of the ore. Not only does the sulphuric acid foul copper plates, but it rapidly destroys silvered plates.

The general grade of Georgian gold ore is low, averaging about $2 per ton. Extraction percentage is low, being about 50 per cent.; but even with the low-grade ore and low extraction, a profit can be made, owing largely to the cheapness of operation. The Georgia gold fields are nearly dormant at the present time, but are beginning to attract the attention of modern metallurgists, and there is a growing belief that greater activity will be seen within the next few years.

Concentration of Old Tailings

A novel milling proposition has been undertaken in Colorado by Messrs. Otto Mears and A. R. Wilfley, having for its object the recovery of tailings from a mountain lake and their reconcentration. The Silver Lake mine at Silverton, Colorado, is one of the famous properties of the San Juan region. Like most San Juan mines, the Silver Lake is high in the mountains, being at an altitude of over 13,000 feet. The first mill erected for the concentration of the ore was located at the mine, and discharged its tailings into Silver Lake. The quantity of the material thus accumulated is estimated at about 500,000 tons. This was before the advent of the modern concentrating machinery, and the tailings are probably much richer than would be tolerated under modern conditions.

Some time ago the gentlemen above mentioned projected a plan for the recovery and reconcentration of these tailings, and ultimately began work on a plan which is expected to yield a considerable profit. The tailings are to be pumped from the lake bed and flumed a distance of several miles, being finally delivered at a new mill erected on the Animas river, at an altitude of about 9000 feet. In the new plant there will be concentrating machinery adapted to the treatment of the material. Wilfley multiple-deck tilting slime concentrators will be a feature of the equipment. The capacity of the plant will be over 500 tons per day. It is expected that the average value of the mill feed will be $3 per ton, and a profit of over $1 per ton is anticipated. Owing to the severity of the winter season in the San Juan, it will be possible to operate this new tailings mill only in the summer.

International Engineering Congress

One of the features of the Panama-Pacific International Exposition in San Francisco, in 1915, will be an International Engineering Congress, embracing all branches of the engineering profession. The date has been set for the week of September 20-25, 1915, which probably is far enough in the future to enable all interested engineers to lay their plans to attend. It is the purpose and object of the congress to gather together engineers from all civilized countries, and offer opportunities for professional and social intercourse. The reading and discussion of papers will be an important feature of the meetings, and the publication of these papers and discussions in suitable volumes will form a permanent record of the transactions. A tentative division of the general engineering field into eleven sections, and the proposed publication of ten volumes of papers, one for each important division, form part of the preliminary arrangements now under way. Of special interest to our readers are the sections devoted to mining engineering and metallurgy, electrical engineering and mechanical engineering. The fee for general membership, including a single volume of transactions will be $5. The committee of management is now seeking to get in touch with all engineers who may be interested, and further information can be obtained by communicating with the secretary, W. A. Cattell, Foxcroft Bldg., San Francisco, Cal.

New Copper Smelter for Arizona

The International S. & R. Co., now operating a copper and lead smelter at Tooele, Utah, has commenced construction of a new copper smelter near Miami, Ariz. This plant is being erected for the treatment of the concentrates that will soon be forthcoming from the new mill of the Inspiration Company. It is not unlikely, also, that an arrangement will be made whereby the concentrates of the Miami mill, now being sent under contract to Cananea, Mexico, will ultimately be treated by the new smelter. The plant will consist of three modern reverberatory furnaces, possibly one blast furnace and a complement of converters. Considering the immense amount of construction work now under way on copper mills and smelters in Arizona, the addition of a new plant will make this state the most active among Western copper producing states. Needless to say the new plant will be a model of its kind, and unsurpassed by any in the country.

Company Reports

The fifth annual report of **Stratton's Independence, Ltd.**, has just been issued, covering operations to June 30, 1913. During the period under review the mill treated 104,111 tons of dump ore and 25,999 tons of mine ore, totaling 130,110 tons. The average grade of the ore was 0.1538 oz. gold per ton. The total gold content of ore treated was 20,013 oz. gold, and the recovery was 15,707 oz., or 78.48 per cent. The recovery in concentrates was 34.43 per cent. and in cyanide bullion 44.05 per cent. The percentage extraction is higher than for several years previous. The percentages of recovery from concentrates and bullion are practically reversed from those reported for previous years. Two grades of concentrates are produced; the first grade averaged 4.118 oz. gold per ton, and the second 1.847 oz. All concentrates were sold to smelters. The cost of milling was $1.32 per ton, divided as follows: Coarse crushing and sorting, 17 cents per ton; fine crushing, concentrating and treating concentrate, 52 cents; cyaniding and special chemicals, 50 cents; miscellaneous, 13 cents. The cost of mining dump ore was 12 cents per ton, making a total cost of $1.44 per ton. The average tonnage milled for the fiscal year was 10,842 tons per month. The managers of the property expect to improve results this year.

The **Messina (Transvaal) Development Co., Ltd.**, operating copper mines and reduction works in South Africa, has issued a report for the quarter ended September 30, 1913. This company is one on which Camp Bird, Ltd., holds option for a large number of shares. The first reverberatory smelting furnace was started last July and the second furnace in August. A small calcining furnace was completed and started in September. Two additional reverberatory furnaces are to be added to the equipment and a mechanical roasting furnace also will be built. The report shows that during the quarter

the mill produced 1207 tons of 44 per cent. copper concentrates and 918 tons of 8 per cent. middlings. The smelting plant produced during the two months of operation in the quarter 134 tons of 50 per cent. copper matte. This company is just coming into the producing stage after twelve years of development work. A railroad is practically completed to the property and operations are expected to go forward much faster from this time on.

The Iron and Steel Market

At the close of December a slight improvement is noticeable in the general tone of the iron and steel markets. By the close of November the curve of descending prices in both pig-iron and steel products was trending around to the horizontal and during December the trend has been still more marked. The concavity of the curve is clearly discernible and while this fact is not conclusive as to the future course of the market it is at least a strong indication, for iron and steel prices generally move in great swings.

Prices are not as low, by about 50 cents a ton in pig iron and about $2 a ton in unfinished and finished steel, as they were two years ago when the market made its great descent, to the lowest level since 1904 in pig iron and the lowest level in finished steel since the early part of 1899. It is claimed, however, that the cost of production has meanwhile increased, and that furthermore producers are firmly set against permitting the market to reach a profitless level. Curiously enough, the reduction in the tariff is mentioned as one cause of this resistance to declines. It is suggested that in the past producers were able to average high and low prices, but since the reduced tariff now precludes high prices being attained, sellers must be careful not to allow very low prices to be attained at all. Probably there is something in the argument, for with the chance of importing material before then, it would be more difficult to stampede buyers into purchasing on a rising market.

In the fore part of December steel mills operations were at about the same rate as at the close of November, about 50 per cent of full capacity, but with extensive closing of plants over the holidays the month's production and shipments have probably not been much above 40 per cent of capacity. There is clear prospect of heavier tonnage in January, this probably to be followed by continued improvement in following months.

Despite the unfavorable sentiment that has been so prevalent, close analysis fails to disclose anything radically wrong with the country. Thus far the tariff reduction has shown itself far less dangerous than was predicted. October, the first month of the new tariff, which became law on the night of October 3, showed inconsequential iron and steel imports, practically no increase over August and September, and a great reduction as compared with the earlier months of the year, while the country's general balance of trade was the greatest for any month in history. The currency question is settled and criticism of the new arrangement is likely to subside. The trust question is next in order for discussion at Washington, and the discussion can hardly prove as disturbing an element as has been the uncertainty of business men as to what they could do and what they could not do. In nearly all quarters it has been agreed that settlement in almost any fashion would be better than the uncertainty.

Pig Iron

The market was a dull and dragging one in the fore part of December, but just after the middle of the month it developed that two important interests, the International Harvester Company and the American Steel Foundries, had made important purchases, involving 50,000 to 75,000 tons, for forward delivery, this constituting the first forward business of any magnitude closed since midsummer, and it is not improbable that after the turn of the year the pig iron markets will feel some stimulus in consequence. Prices are very low and production appears to have been restricted to the full extent required by reduced consumption, if indeed the restriction has not gone too far. Declines since last report have been light. Quotations are: No. 2 foundry, f.o.b. Birmingham, $10.50 to $11; No. 2 X foundry, delivered, Philadelphia, $15 to $15.25; No. 2 X, f.o.b. Buffalo furnaces, $12.75 to $13; No. 2 foundry, delivered, Cleveland, $13.50; No. 2 foundry, f.o.b. Chicago furnaces, $14; at Valley furnaces (90 cents higher delivered Pittsburgh), Bessemer, $15; basic, $12.75; malleable, $13.50; No. 2 foundry, $13.50; forge, $13.15. Ferromanganese was reduced $3 a ton early in December and is quotable at $47, f.o.b. Baltimore, for English or German, prompt or forward.

Steel

December settlements of prices on monthly adjustment contracts were on the basis of $20 for billets and $21 for sheet bars, at maker's mill, Pittsburgh or Youngstown. In some instances slight concessions are understood to have been made, but these figures closely represent the quotable market. Rods have softened to $25.50, Pittsburgh. The market is stronger in tone in that mills refuse to sell billets or sheet bars for second quarter at prevailing prices, and even for first quarter are not always willing to sell Bessemer at the same level as open-hearth. They claim the production cost is higher for Bessemer. Frequently open-hearth steel has commanded a premium over Bessemer, and the relation probably depends more on situation as to demand and supply than on the situation as to cost of production.

Finished Steel

Since last report plates, shapes and bars have declined $1 a ton, the declines occurring early in December, since when the market has been stationary. Quotations now named can occasionally be shaded in the case of large tonnages for prompt shipment, the mills being rather averse to loading up with contract tonnage even at the full quoted prices. Sheets and wire products have also declined $1 a ton, and are not overly firm, for prompt shipment at the new quotations. Prices are f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard section, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.20c.

Shapes, 1.25c.

Steel bars, 1.20c., base.

Iron bars, 1.35c. Pittsburgh, 1.10c. Chicago, 1.22½c. Philadelphia.

Wire nails, $1.55 per keg, base; plain wire, 1.35c., base.

Sheets, blue annealed, 10 gage, 1.50c.; black, 28 gage, 1.90c.; galvanized, 28 gage, 2.90c.; painted corrugated, 28 gage, 2.10c.; galvanized corrugated, 2.95c.

Merchant steel pipe, ¾ to 3-in., 80 per cent off list.

Steel boiler tubes, 3½ to 4½-in., 69 per cent off list.

Standard railroad spikes, 1.50c. Pittsburgh, 1.55c. Chicago.

Button head structural rivets, 1.75c.; cone head boiler rivets, 1.85c.

Cold rolled shafting, 62 per cent off list.

Cyanidation in the Mercur District, Utah, is the title of a pamphlet recently issued by the *Salt Lake Mining Review*, giving a history of metallurgical operations in a famous mining district, where the modern vacuum filter was invented. The pamphlet contains many illustrations of milling operations.

The Non-Ferrous Metal Market

The metal markets generally have been dull, and prices have had a steady tendency downward since our last report. Stocks of metals have accumulated, and purchasers have not been active in spite of lower prices. This fact has led to the belief that even a lower level will have to be reached before buyers will again enter the market.

Copper.—About the middle of December prices became practically nominal and the producers sold metal for what they could get. Some foreign business has been done, but the domestic market has been dull. Lake copper is quoted nominally at 14¾c. to 15c., this being practically the price asked by Calumet & Hecla, which is the only Lake producer which has much metal for sale. Electrolytic is quoted at 14.05c. to 14.15c.

Tin.—The domestic market has reflected the weak condition of the London market and little business has been done. December tin is lower, being quoted at 37½c.

Lead.—Since our last report the leading producer has made two cuts in the price for this metal, and conditions are being reached where some mines will not be able to produce at a profit. New York lead is quoted at 4c. per lb., and St. Louis at 3.85c.

Spelter.—This market has been decidedly weak and prices have suffered a sharp decline. Stocks of spelter are accumulating, but buyers remain out of the market. It is felt, however, that prices will not go lower, as buyers are not well covered, and must soon enter the market. New York spelter is quoted at 5.10c. to 5.15c., and St. Louis at 4.95c. to 5c.

Other Metals.—The aluminium market is quiet and only a moderate business is done. Prices are 18¾c. to 19¼c. for No. 1 ingots. A similar situation prevails in the antimony market; prices are inclined to be weak, and range from 6c. to 7⅝c. for various brands. The quicksilver market is more steady with fair prices prevailing. New York quotes $39 to $40 per flask of 75 lb., and San Francisco $39.

Symposium of Papers on the Power Problem in the Electrolytic Deposition of Metals

Joint Meeting of the American Institute of Electrical Engineers and the New York Section of the American Electrochemical Society

The next meeting of the New York Section of the American Electrochemical Society will be a joint one with the American Institute of Electrical Engineers and the New York Section of the American Society of Mechanical Engineers, at 8:15 p. m., Friday, Jan. 9, 1914, in the auditorium of the Engineering Societies Building, 29 West Thirty-ninth Street, New York City. Dr. C. O. Mailloux will preside. After the meeting members of the section will be the guests of the A. I. E. E. at a smoker to be held in the rooms of the Institute.

The subject for the evening is "The Power Problem in the Electrolytic Deposition of Metals," and the program is as follows:

The Limitations of the Problem. By LAWRENCE ADDICKS, Supt. United States Metals Refining Company. (A brief statement of the conditions imposed by practice in the electrolytic refining of copper as a typical process.)

The Mechanical Side of the Problem. By H. E. LONGWELL, Mech. Engineer, Westinghouse Machine Company. (Application of gas and steam for driving generators of the type required.)

The Electrical Side of the Problem. By F. D. NEWBURY, Division Engineer, Westinghouse Elec. & Mfg. Company. (Application of various d.c. and a.c.-d.c. apparatus to furnish current of the required dimensions.)

The papers will be illustrated and the discussion should be interesting, as the subject is much broader than the typical case chosen for the formal papers.

Meeting of Secretaries of National Technical Societies

Following a call sent out by W. M. Corse, Secretary of the American Institute of Metals, for a meeting to discuss the question of avoiding conflict of dates in the meetings of national, scientific and engineering societies, representatives of fifteen national societies met in the reception room of the American Institute of Mining Engineers, New York City, on Saturday, December 13, 1913. The following American societies were represented by their Secretaries: American Society of Mechanical Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, American Chemical Society, American Electrochemical Society, American Institute of Metals, American Institute of Chemical Engineers, American Society for Testing Materials, National Electric Light Association, American Efficiency Society, American Gas Institute, American Society of Gas Lighting, Franklin Institute; besides these, H. D. Vought represented the Railway Engineers and David H. Browne the Canadian Mining Institute. Secretary Stoughton, of the Mining Engineers, served as chairman and W. M. Corse as secretary *pro tem.*

After a long and spirited discussion of various questions needing adjustment, and which it was thought could best be handled by co-operation between the secretaries of the various national societies, the following committee was appointed to serve *pro tem* as a clearing house for announcing to the societies represented the dates of meetings which have been already fixed for 1914, and announcing others as they may be hereafter fixed; also to confer with a similar committee of the Railway Association Secretaries to see whether the two committees could not work in unison, or adopt some uniform plan for future regulation of these questions: W. M. Corse, *chairman;* J. C. Olsen, F. L. Hutchinson, C. W. Rice; Bradley Stoughton, *secretary.* This committee will hold a meeting with the other committee mentioned in the rooms of the American Railway Association, Underwood Building, New York City, on January 10 next at 11 a. m.

It is to be confidently hoped that this move will either stop or reduce to an unavoidable minimum the conflicts of dates in meetings of national societies, which have certainly been annoyingly frequent during 1913.

The Faraday Society

The annual general meeting of the Faraday Society was held on Wednesday, November 26, 1913, at the Institution of Electrical Engineers, in London. The following officers and council were elected to serve for the year 1913-14:

President—Sir Robert Hadfield, F.R.S.

Vice-Presidents—G. T. Beilby, F.R.S.; Professor K. Birkeland, W. R. Bousfield, K.C.; Professor Bertram Hopkinson, F.R.S.; Professor A. K. Huntington, T. Martin Lowry, D.Sc.; Alexander Siemens, M.Inst.C.E.

Treasurer—F. Mollwo Perkin, Ph.D.

Council—R. Belfield, Dr. H. Borns, W. R. Cooper, Professor F. G. Donnan, F.R.S.; Emil Hatschek, Dr. R. S. Hutton, Professor Alfred W. Porter, F.R.S.; E. H. Rayner, Dr. R. Seligman, Maurice Solomon.

The seventieth ordinary meeting of the Faraday Society was subsequently held.

A paper communicated by Mr. **Ernest Vanstone** (Birmingham) on *The Electrical Conductivities of Sodium Amalgams* was read in abstract by the secretary.

Continuing the physico-chemical investigation of sodium amalgams the author has determined the electrical conductivities of about twenty alloys. The composition of the alloys varied from 100 atoms per cent. sodium to 54 atoms per cent.

In order to obtain a sufficiently long thread of metal for resistance measurements the alloys were drawn up into a capillary spiral 1 mm diameter and about a meter in length when unwound; platinum terminals were sealed in the spiral at points about a meter apart.

The resistances were measured by a compensation method. Great difficulty was experienced in obtaining a continuous uniform thread.

The conductivity-concentration curve shows discontinuities at concentrations of 15 and 21 per cent mercury and a flat minimum of 35 per cent.

The present paper is a preliminary to a more extensive investigation.

A paper on *The Influence of a Second Solute on the Solubility of Ortho-phthalic Acid*, by **Dr. A. C. Rivett** and **Mr. E. I. Rosenblum**, was read by Dr. Rivett.

The authors have investigated the solubility of orthophthalic acid in solutions of various concentrations of some twenty-six solutes, including twenty-one salts. Their object has been to collect a considerable amount of information which will be available for comparison with similar work on the influence of salts on such other properties of a second solute as diffusion, lowering of freezing point of solvent and reaction velocity.

The form of curve connecting solubility and salt concentration is of the usual type, showing an initial rise followed by a more or less sharp fall. Double decomposition and perhaps increased dissociation of the acid will be partly responsible for the initial rise. In the later part of the curve these become relatively of less importance and at a sufficiently high concentration will be slight compared with the decrease due to so-called neutral salt action. If the curve in its later part be extrapolated to cut the solubility axis at S_o, then S_o represents what the concentration of phthalic acid would be in pure water if those conditions alone ruled in approaching it which determine the later part of the curve. Such extrapolation is possible only where the initial rise is very slight. If now the alteration of saturation concentration of the acid depend upon the ions and molecules present, in whatever way these may act, the relation should hold:

$$S = S_o \left\{ I + k\alpha C + k' (I - \alpha) C \right\}$$

where S is solubility and α is degree of dissociation of the salt at concentration C; k and k' are ionic and molecular constants, respectively, of so-called "neutral salt action."

The authors show that it is possible, by choosing suitable values for k and k', to reproduce the solubilities of phthalic acid in presence of LiCl, NaCl, KCl, $MgCl_2$, $CaCl_2$, $BaCl_2$, HCl, KBr, KI, and $NaNO_3$, up to concentrations of about 1-molar normal, practically within the limit of experimental error. The calculations involve the usual assumptions as to the possibility of obtaining measures of the degrees of dissociation of salts.

Dr. T. Martin Lowry drew attention to the analogous case of the diminution in solubility of gases in water containing salts in solution.

Dr. E. K. Rideal said that it would have been better to experiment with a substance whose molecule was more symmetrical than that of orthophtalic acid and which would "hydrate" in as simple a manner as possible.

Mr. R. E. Slade remarked that it would be interesting to know the dissociation constant of ortho-phthalic acid, but the author was unable to give it. If there were not much double decomposition on the hydration theory why did K_2SO_4 send up the solubility enormously while Na_2SO_4 did not?

The Chairman said he would like to be able to compare the authors' curves with those given by another solute. In the case of organic radicles it was fairly certain they had hardly any water molecules associated with them.

Dr. T. Martin Lowry showed a series of photographs illustrating the *Formation of an Oxidizable Variety of Nitrogen* by the action of a spark discharge on air at atmospheric pressure. The product has the property of being oxidized by ozone to nitrogen peroxide; but if no ozone is added to the gas the yield of peroxide is very small, the greater part of the oxidizable nitrogen reverting under these conditions to the ordinary form. The absorption spectra, which were used to detect and to estimate the nitrogen peroxide, were of interest as having been taken with the help of a column of gas 64 feet in length.

The Chairman said he believed ozone was only produced by a discharge which followed a highly peaked curve.

Professor Alfred W. Porter, F.R.S., in the course of his remarks, referred to the palmleaf-like figures which form, after development, upon photographic plates after passing a negative discharge over them, and which are only obtained in gases containing *free* nitrogen. The figures seemed to indicate that a very loose molecular, ionic, or atomic aggregate travelled with the discharge and ultimately broke up explosively like shrapnel. The immediate product of the explosion was probably Strutt's nitrogen.

A discussion followed on a paper presented at the previous meeting by **Dr. F. J. Brislee** on *The Density of Aluminium*.

The discussion centered round the author's observation that rolling and otherwise working the metal reduces its density, and his explanation of this as due to a transformation from crystalline to amorphous states.

Dr. R. Seligman remarked on the technical importance of the observation, the worked metal being more prone to corrosion because it was amorphous. He agreed as to the probability of the metal changing its state, which would bring it in line with other metals.

Dr. T. Martin Lowry thought that the decrease of density due to rolling might be within the limits of experimental error.

A note communicated to the previous meeting by **Professor J. W. Richards**, of Lehigh University, U.S.A., on *Overvoltage* led to some discussion.

In his note Professor Richards states that it is an error to regard overvoltage as if it did chemical work and was of the nature of decomposition voltage. He regards it as merely due to surface resistance caused by gas on the electrode, so that the energy absorbed appears as sensible heat. This was tested calorimetrically on a voltaic cell.

Dr. F. J. Brislee in a written communication criticized the author's experiments, which seemed to him to prove nothing with regard to the nature of overvoltage. The balance of evidence, however, favored the view that it is associated with the doing of chemical work followed by the degradation of the chemical energy to heat.

Mr. U. R. Evans opposed the view that over-potential was an irreversible electrodic change, involving waste of energy. It required no special explanation, being merely due to the fact that the formation of bubbles required a considerable degree of supersaturation of the cathode with hydrogen. It was a simple phenomenon, quite analogous to superheating a liquid—itself also a surface tension effect.

The Effect of Legislation Upon Chemical Industries

Presidential Address Delivered before the American Institute of Chemical Engineers.

BY T. B. WAGNER

At the end of the eighteenth century an observation was made by Scheele in his laboratory, the results of which have meant more to the prosperity of all peoples inhabiting this planet than any other invention—chemical or otherwise. I am referring to the observation which disclosed the fact that cyanide of potassium is capable of dissolving gold. While this discovery was of much scientific interest at the time, and led Faraday to explain it by an elaborate theory, no industrial application was given to it until about one hundred years later.

In April, 1890, the first plant operating under the McArthur-Forest method for treating ore tailings was started in Johannesburg.

The effect of this process is reflected in a tremendous increase of the world's output of gold; consequently, the cyanide process plays an important part in the monetary system of the world, as the increased gold production effected by it has dispelled the fear that there might not be enough of the precious metal to maintain the gold standard of the civilized nations. The struggle in this country for the maintenance of the gold standard is within the memory of all, but I fear that like in other instances, credit was not given to the chemist for his share in having the gold standard preserved.

The recital of this invention has no immediate bearing upon my subject, except in so far as it goes to prove that the furtherance of civilization and the furtherance of industries depend largely upon underlying conditions, which, in their incipiency, may seem trivial. That is the case with the effect of legislation upon the development of chemical industries. The chemical industries of the world are a little over 100 years old, yet, in point of advancement and financial returns, their success is without a rival. Strange as it may seem, the starting of industrial enterprises is not always due to the chase for the almighty dollar, as is generally and perhaps pardonably assumed, but in many instances it is directly caused by the enactment of laws with more or less restrictive tendencies.

Let us go back to the birth of the chemical industries in the beginning of the last century. Napoleon the First whose fame as a stateman and as a conqueror will stand like a beacon light as long as history shall be written, was at war with England. To crush his rival, this far-sighted statesman conceived the idea that the most effective way of accomplishing his purpose lay in the crippling of England's trade. The Continent naturally was the principal buyer of England's colonial products. Napoleon, therefore, in 1806, issued a ukase, according to which England's colonial products were barred from the Continent, and all trade relations with England were forbidden; any country violating this ukase was apt to find itself involved in war with France. This ukase is known as Napoleon's "colonial blockade."

Among England's most important colonial products was cane sugar, but with the enforcement of the blockade, the Continent found itself unable to obtain this sweetening agent, without which life seems to be less sweet indeed. The price of sugar rose enormously and an impetus was thus given to the exploitation of the discovery of Margraf, made in 1747, that the ordinary garden beet root contained considerable quantities of sugar, identical with that found in the sugar cane. The first factory was built in Germany in 1801. Since then this industry has had a marvelous growth, and the present production of sugar from this source exceeds that from cane. The world's production of sugar today is 18,500,000 tons, of which 9,000,000 tons are obtained from the sugar cane, and 9,500,000 tons from the sugar beet.

Of the latter only a little over 600,000 tons are produced in this country, the factories engaged in its manufacture numbering seventy-two.

Incidentally I might mention that while at the beginning of the industry about 20 tons of beets were required for the production of 1 ton of sugar, the same amount of sugar is now obtained from only 7 tons of beets.

It is also worthy of mention here that all of the potassium contained in the sugar beets and fully 65 per cent of their contents of nitrogen are recovered from the molasses and utilized over again. What effect the latest legislation, the new tariff, will have upon the industry in this country, whether it will prove that it has outgrown the state of an infant industry, or whether it still requires the friendly and substantial support of a high protective tariff—that the future will demonstrate within a few years.

Coincident with the establishment of the beet sugar industry was that of another industry which was destined to play an important part in the economic conditions of this country and Germany, viz., the production of grape sugar from starch. The success of this new industry, it may be rightly assumed, is also attributable to Napoleon's exclusion of England's cane sugar from the Continent. The conversion of starch into a reducing sugar, by means of a dilute acid and heat, was discovered in 1811 by Kirchhoff, a teacher at the Imperial Academy of Sciences at St. Petersburg, and the first factory was built in Germany in the same year by the Grand Duke of Saxe-Weimar, at the instance of Professor Doebereiner of the University of Jena, whom you will remember as the inventor of the first "hydrogen lamp."

Bearing in mind the present magnitude of this industry, it is interesting to read of the financing of this pioneer factory in Germany.

I quote from a letter of the Grand Duke to Professor Doebereiner:

"The subscription is assured; my wife and I, my son and his wife are the four stockholders, each contributing 100 talers. I shall advance the capital of 400 talers, which is to bear interest at 5 per cent, and shall turn this over to you; you may then proceed immediately to start the plant. I shall deed my shares to you; I wish you every success and I am convinced that you will proceed carefully. As regards the concession, I believe it can be arranged that it shall be granted for a period of years, however, it must not include the home production of syrup for home use. I intend coming to Jena this week; I shall then bring the money with me and we may discuss further details. I have

looked up the manufacture of sulphuric acid in Chaptal & Klaproth. It seems to require a large capital, however, to build the lead chamber."

From this small beginning the industry has grown into one of vast proportions, the yearly production in Germany being 120,000,000 lb., and whereas, at the start, only grape sugar and syrup were produced, and the potato was the only form of raw material, at present by far the largest amount is produced from Indian corn and the number of different commercial commodities produced from the latter reaches almost one hundred. The industry consumes in this country about 50,000,000 bu. of corn annually, or practically one-sixth of all the corn which reaches the markets.

These figures must not be interpreted as meaning a steady and unhampered growth of the industry. On the contrary, if all the legislation which was enacted had had the effect anticipated at the time of enactment, the industry would not have survived these attacks.

For instance, in various states laws were passed putting glucose and grape sugar in the same category as poisons and prohibiting their use in food products. Only last year attempts were made in the legislatures of two states to exclude glucose from use in confectionery, although it is conceded that its use results in a better grade of candy and that certain goods cannot be made without it.

Again when it was discovered by Dr. Ludwig Gall that grape sugar lends itself admirably to the improving of wines, in which the amount of sugar produced by nature is deficient on account of adverse climatic conditions, this method of ameliorating wines, which has come to be known as "Gallizing," was hailed in Germany as one of the most important discoveries, affecting and improving the economic conditions of the provinces in which the wines were produced. Owing to the large demand which Dr. Gall's discovery created for this sugar, it contributed materially to the growth of the industry. Yet we find that only a few years ago conditions were reversed by legislative action and great restrictions were placed upon the use of this sugar in the amelioration of wines.

In this country the controversy over the use of sugar in wines, only a few months ago, almost caused the failure of the new tariff act. Our domestic wine industry is centered principally in the State of California one one side, and the States of Ohio and Missouri on the other. California produces grapes rich in sugar, whereas even the best grapes produced in Ohio are deficient in sugar to such an extent as to produce a wine so low in alcohol as to be almost unmerchantable. The Ohio and Missouri wine producers therefore resorted to "Gallizing" ever since the industry was started in their states, about 60 years ago. Their ameliorated wines are said to be as good as any produced in California, yet the wine producers of that State tried to create the impression in Congress and elsewhere that California wines were the only pure wines, whereas those produced in Ohio and Missouri were adulterated because of the addition of sugar.

In the production of sweet wines it becomes necessary to "fortify" the wines with brandy, and the California people succeeded in having an act passed by Congress in 1890 which permitted them to use brandy without paying the spirit tax of $1.10. It is said that since the passage of this act the amount of money saved to the California interests was not less than $63,000,000.

To retaliate against California, the Ohio and Missouri interests appeared before Congress when the Underwood tariff bill was under consideration. One section of the tariff act deals with the income derived from internal revenue, and here the Eastern interests saw their opportunity and introduced a bill which would take from the California wine producers the privilege of using tax-free brandy. It would compel them to pay into the United States Treasury annually something like $8,000,000.

The California interests answered in kind by introducing a bill placing a tax of 25 cents per gallon upon all wines produced in the territory east of the Rocky Mountains, which, if enacted into law, would mean the annihilation of the industry in that territory. This in turn would injure the grape sugar industry, as it would curtail the consumption of grape sugar.

Further consideration of the tariff bill came to a standstill, as this so-called wine clause proved the stumbling block, and no headway was made until the entire wine clause was eliminated for the time being—Congress agreeing to give it its attention during the regular session.

I cite these cases to show the influence of legislation, even though indirect, upon the development of a chemical industry. What is one's loss is another's gain. For instance, the loss of the sugar business to England meant the birth of two important new industries and these in turn influenced the development of other branches of the chemical industries. It is but fair to state that the chemical industries in general owe a great deal to the beet sugar industry. Looking over the list of early chemists and chemical engineers, who have distinguished themselves in the chemical industries, we find that most of them had their start in a beet sugar factory—likewise many successful works managers, for it was in this industry that the first complicated machinery was installed. The modern evaporating devices as well as the separation of solids from liquids by centrifugal force, had their inception in beet sugar works.

I cannot leave this chapter without mentioning another instance bearing upon the beneficial, although unlooked for, results of restrictive legislation. A number of years ago a law was enacted in one of the wine-producing countries abroad with reference to wines made from the residue of the pressings of the grapes, the so-called "pomace" wines. These wines were introduced by Petiot, a French wine merchant, and were produced from Bordeaux wines by adding a sugar solution to the residue from the first must and fermenting a second time. The alcohol generated thereby dissolved coloring substances, as well as tannin and the flavoring principles, the "bouquet." This treatment is known as "petiotizing" and is applied to Bordeaux wines four or five times in succession.

Much sophistication was practiced—the pomace wines being sold frequently as natural wines. The Government recognized the legitimacy of the "pomace" wine business, but it wanted these wines to be sold for what they were and did not want them sold to the public under a misleading name. The wines were supposed to be sold as "pomace wines," and to enable the Government officers to distinguish them from "natural" wines, and to identify a pomace wine, the law provided that these wines must receive, before marketing, the addition of a small amount of phenolphthalein. The inspector would examine the wines by adding a few drops of an alkaline solution which, of course, would turn the color red. If the color of a "natural" wine turned red it was *prima facie* evidence that a pomace wine had been substituted.

After this law had been in effect for about a year it was observed that peasants living in the district where these pomace wines were produced and consuming rather large quantities of these wines developed what was then considered a disease and which assumed the proportions of an epidemic. The Government dispatched its medical

officers to make a thorough investigation and subsequently they reported that they believed phenolphthalein to be the cause of the trouble. Thereupon clinical tests were instituted and the fact established that phenolphthalein was a most effective cathartic. While heretofore phenolphthalein was used primarily in the laboratories as an indicator, it now assumed an important position among our therapeutic chemicals and is at present manufactured in very large quantities.

Before leaving the subject of sugars, I must not omit a reference to saccharine, a substance which has received extensive attention at the hand of legislative bodies. As you know, saccharine was discovered by Dr. Fahlberg, while taking a post graduate course with Professor Ira Remsen at Johns Hopkins University. It was more or less an accidental discovery, as Dr. Fahlberg's work was in the direction of coal tar derivatives from a purely scientific point of view. The manufacture of this new sweetening agent was started in Germany and a new industry created which grew in importance so that it was eventually considered a menace to the beet sugar industry of the Continent.

The latter, of course, is of greater importance to Continental countries, from an economic point of view, and the new rival of beet sugar was therefore discriminated against by laws which prohibited the use of this sweetening substance as a substitute for sugar, permitting its employment solely for medical purposes, the Governments of Germany and Italy going so far as to prohibit the manufacture of the article itself. It was not prohibited because the article was injurious to health, but simply because of economic considerations. The importation into Germany being prohibited, it is interesting to note the accounts in the trade papers of the vast amount of smuggling from Switzerland into Germany.

Incidentally this shows that notwithstanding the prohibition of saccharine in food, a large demand for it still exists, and I am told that it is used chiefly in the households for sweetening jellies, jams, preserves and similar products in place of the expensive beet sugar, rather than by the manufacturers of such products. I read an account in one of the trade journals recently, according to which it was observed for some time by the Customs authorities that an astonishingly large number of funeral parties crossed the Swiss frontier into the adjoining Grand Duchy of Baden—the explanation given being that the bodies were shipped into Germany in conformity with the wishes of the deceased to be buried in their native land. The number of funeral parties steadily growing in numbers, the Customs authorities finally had their suspicions aroused and ordered a casket to be opened. It was discovered that in place of the supposed corpse, the casket was filled with packages of saccharine!

The most far-reaching legislation ever enacted was that directed against the discharge of sulphurous acid fumes from ore smelters. With the increased output of these smelters, the volume of sulphurous acid discharged into the air became so large as to produce a most destructive effect upon vegetation. Laws were enacted in this country, as well as abroad, to the effect that unless the sulphurous acid fumes could be rendered harmless the operation of these smelters would have to be stopped. The first attempts to convert them into a useful article were in the direction of compressing the gases into liquid sulphurous acid, which was used in the manufacture of glue and gelatine, but the amount of gas recovered from the furnaces grow so enormous that this outlet was not sufficient.

The attempts were then directed to oxidizing the sulphurous acid by means of the oxygen of the air for the production of sulphuric trioxide, following the reaction discovered by Clemens Winkler. These efforts proved extremely successful and works were soon established where $S O_2$ and finally sulphuric acid was generated from the waste sulphurous acid gases. In this manner a new process for manufacturing sulphuric acid was created, the so-called "contact process," which, in the course of time, thoroughly revolutionized a branch of chemical industry, in which the old established chamber process had come to be considered impossible of improvement.

I am particularly pleased to be able to refer in this connection to the splendid work of our fellow member, Mr. J. B. Francis Herreshoff, whose contact process has proved so superior to that of the Badische Anilin and Sodafabrik in point of economy and simplicity of operation that it is now being introduced into Germany.

The utilization of the waste gases from smelters had the effect of producing cheap sulphuric acid in localities where it would have been impossible to produce it by any other method. This had the most beneficial effect upon the development of the fertilizer industry in this country. Our Southern States, principally Florida and Tennessee, furnish today the bulk of the world's requirements of phosphatic rock. Liebig showed us how this insoluble phosphorus could be converted into a soluble form by a treatment with sulphuric acid, and for this purpose alone over 3,000,000 tons of acid are used per year.

The contact process, in turn, was responsible for the successful commercial production of synthetic indigo. The most successful method of producing it is a combination of methods suggested independently of each other, and consists in the following steps:

1. Naphthalene to phthalic acid.
2. Phthalic acid anhydride to phthalic imide.
3. Phthalic imide to anthranilic acid.
4. Anthranilic acid to phenylglycin ortho carbonic acid.

5—Phenylglycin ortho carbonic acid to indigo.

The greatest problem was the production of phthalic acid. Heretofore it has been obtained through the oxidation of naphthalene by chromic acid. The latter, however, was very expensive and this method did not hold out much hope of commercial success. E. Sapper, a chemist engaged in experiments to reduce the cost of production of phthalic acid, conceived a new process of making it by heating naphthalene with highly concentrated fuming sulphuric acid. After years of experimenting a suitable method was found in the discovery of which Accident, the patron saint of the inventor, played an important rôle. It was discovered that the addition of mercury to the solution of naphthalene in fuming sulphuric acid facilitated the reaction and resulted in an almost theoretical yield.

We must bear in mind, however, that the commercial success of synthetic indigo was influenced, to a large extent, by the fact that the $S O_2$ generated by the process of heating naphthalene with sulphuric acid could be reconverted into $S O_3$ by the contact process. Even 10 years ago one single establishment engaged in the manufacture of synthetic indigo reconverted into $S O_3$ 40,000 tons of sulphurous acid per year, obtained in the manufacture of phthalic acid.

Thus we have seen that through the instrumentality of the law, a chemical process was introduced into metallurgical establishments, the contact process was created, a cheap supply of sulphuric acid was secured, which in turn proved a blessing to agricultural interests through the production of a cheap fertilizing material, and finally it made possible the commercial exploitation of one of the finest achievements of scientific effort—the production of synthetic indigo.

Another impetus was given to chemical industries by laws aimed at stopping the contamination and pollution of rivers and other waters. Before the value of by-products was understood by manufacturers, the rivers and waterways in general were used as the most convenient and inexpensive way of removing offal and waste of all kinds from the factory.

It is not difficult to understand the results from such abuse of natural water courses. The communities deriving their supply of drinking water from these sources were especially affected by it; the water, deprived of its natural content of oxygen, caused the death of the fish habitating in these waters and the odor produced by the decomposition of this offal brought much discomfort to the people living within the vicinity of such streams. It was a condition of which the Legislatures were compelled to take cognizance, and the inevitable result was the prohibition of such use.

This legislation proved disastrous to many industries but it proved of the greatest benefit to a far larger number. Among others, it affected beneficially all the industries connected with fermentation and those connected with the manufacture of starch from various raw materials. The materials recovered from the waste of these industries were converted into dry form, serving, in most instances, for the feeding of cattle and live stock. Such feeds are those produced from the starch works, distilleries and breweries, and they rank among the most valuable concentrated feeding stuffs. They are indispensable for the rational feeding of live stock, which, together with wheat, form the principal means of sustenance of mankind. The production in this country of foodstuffs from the manufacture of starch alone amounts to over 300,000 tons per year, and since these foodstuffs sell at approximately $25 a ton, the revenue obtained from this source amounts to $7,500,000 per annum.

In former years it was customary to allow the germs of the corn to go to waste, but today the industry recovers about 75,000,000 lb. of oil per year, which is sold in the markets of the world at about $4,500,000. The corn solubles—the so-called steep water—is now recovered to the extent of 100,000,000 lbs. a year, which is sold also in the world's markets at over $1,000,000. The by-products recovered from distilleries and breweries in this country may be said to be worth about $5,000,000 per year.

One of the most prolific sources of legislation is oleomargarine. Laws have been enacted in many States aimed at the destruction of this industry, as for instance the oleomargarine laws of Pennsylvania and New Hampshire, which required that no oleomargarine should be sold in those States unless it were colored pink. Yet, in spite of these restrictive, if not prohibitive, laws, this industry has prospered, simply because of the underlying merit of the product itself. This is well illustrated by the fact that the receipts of the internal revenue office from the tax on oleomargarine amounted to $1,259,987.65 during the fiscal year ending June 30, 1913.

This subject furnishes a most interesting sidelight on the incongruities of laws. The artificial coloring of natural butter is permitted by a special act of Congress, even though the butter color used at the time of the enactment of this law would not be permitted today under the Federal Food & Drugs Act because of its injurious character.

The artificial coloring of oleomargarine, however, is not permitted, because such practice would make it an imitation of butter. If, however, the producer of oleomargarine is willing to pay a tax of 10 cents per pound, he then acquires the right to put his "fraudulent" product upon the market and the Government becomes his silent partner. Most of the oleomargarine is produced by the packers, but it is only one of a large number of chemical products manufactured by them.

It is only a relatively short time since chemistry has entered the packing houses and it was not entirely a matter of choice that led to the entry of the chemist, but rather stern necessity, for the law had served notice upon the packers that a stop would soon be put to their practice of discharging their enormous putrefactive wastes into creeks and rivers. This could not be accomplished without the aid of the chemist and the chemical engineer.

As a result of their work, the packers produce today not only meats, meat extracts and soups, but they manufacture lard, tallow, stearine and oleomargarine. They also produce soaps, candles and hydrogenated fats; in the manufacture of these products, they recover glycerin as a by-product. From the different parts of the animal, especially from the pancreas, the thyroid and the suprarenal glands, therapeutic agents of great medicinal value are obtained.

From the stomachs of hogs pepsin is produced and the use of the latter has been greatly increased within recent years by the clever discovery of two brother chemists, the Messrs. Wallerstein of this city, that beer of absolute chill-proof quality is obtained by the use of pepsin. The governing thought of their invention lay in the desire to keep those albumenoid substances in colloidal solution which could not be separated during the process of refrigeration; the use of a minute quantity of pepsin makes this possible.

Further by-products of the packing houses are glue and gelatine, both products of great importance, particularly in view of the universal shortage all over the world of glue stock, and the correspondingly high prices prevailing for these products. The bones of the slaughtered animals are charred for the preparation of bone black, which, as you know, is a valuable filtering and refining material. In other departments of the packing plants brushes are made from the bristles of the hogs. The hair is also recovered and the skins and hides go to the tanneries to be converted into leather. What is left is placed on the market as fertilizing materials, as for instance, dried blood and tankage.

Viewing these remarkable results, it is obvious that there is hardly any necessity of further legislation for the disposition of offal from the packing plants.

Other industries directly affected by legislation prohibiting the pollution of streams are the paper and pulp industries. Here, however, the problem of a satisfactory disposition of the objectionable materials offers greater difficulties than in most of the other industries. Some of the waste material is recovered through mechanical separators, but most of it still goes to waste, and this has resulted in the closing by law of a number of plants.

A beginning towards recovery has been made through the Mueller-Kestner process whereby the spent sulfite liquors are neutralized and then concentrated in a vacuum system. The liquid thus obtained is used principally for laying dust on roads in the same manner as petroleum oils are used in this country.

In Sweden attempts are being made to produce ethyl alcohol from sulfite liquors and the results are claimed to be quite satisfactory, but while these are steps in the right direction, the great problem affecting these industries still remains unsolved.

In this connection I do not think it amiss to point out another incongruity of laws as enforced in various countries and the discrimination shown against certain products. One of the greatest wastes in this country is that of the lumber industry. The waste in that partic-

ular industry is appalling and when we recall the strenuous efforts toward conservation of our natural resources, one stands aghast at the wanton waste still going on in that industry, for wherever you see a lumber mill of large capacity you will invariably find a burner installed where such wood waste as cannot be used in the production of steam is incinerated, and millions of dollars worth of material escapes unused into the air in the form of gases.

During the last few years an industry has been started in this country based upon the observation that cellulosic materials can be converted into reducing sugars, from which ethyl alcohol may be produced. There is only one plant in operation thus far, but the results obtained seem to indicate that this new method of producing ethyl alcohol is commercially feasible and lucrative The cash capital invested in this plant amounts to $1,000,000. The product obtained is of the very highest grade, practically free from fusel oils and surpassing that produced in grain distilleries, yet the most natural outlet for ethyl alcohol is closed to this industry, because our laws provide that only grain-distilled spirits may be used in the compounding of whiskeys. In Canada, however, no such restrictive legislation exists because there the law simply provides that ethyl alcohol may be used irrespective of its source. It would not be surprising, therefore, if the development of this new industry would prove speedier in Canada than in this country.

Of much interest to chemists is a bill recently introduced in Congress by Representative Falson of North Carolina, providing for an appropriation of $400,000 to enable the Department of Agriculture to procure economical methods for the production of artificial fertilizers by means of electricity. It would seem that official circles have taken cognizance of the fact that the saltpetre deposits in Chile are not far from complete exhaustion, and that our lawmakers have arrived at the conclusion that they can rely upon the chemist to meet the situation—producing a cheap nitrogenous fertilizing material in place of saltpetre, which can be secured in unlimited quantities.

You all know that the utilization of nitrogen from the air by the combination of nitrogen and oxygen of the atmosphere with the formation of nitric acid is an accomplished fact.

In the form of a new chemical compound, called calcium cyanamide, which is produced by combining nitrogen from the air with calcium carbide, a plant food is obtained which, as a fertilizing agent, is as efficient as Chile saltpetre or ammonium sulphate. The production of these substances from atmospheric nitrogen will therefore remove the anxiety of many writers on economics concerning the difficulty of feeding an ever-increasing population, owing to the gradual exhaustion of the soil.

Since nitric acid is also used largely for nitrating glycerin, cotton and cellulose, and since these nitrated products are the principal constituents of the smokeless powder and high explosives used by the armies and navies of the world, it is apparent that aside from its importance from economic considerations, a process of making nitric acid independently of Chile saltpetre will become of extreme importance in case of war, for it removes the danger of being cut off from the supply of Chile saltpetre by a hostile navy.

As yet, the principal production of nitric acid from atmospheric nitrogen is centered in Norway, because that country has natural water power of a tremendous magnitude, with the further advantage of being located within easy reach of the principal markets abroad. Even in Norway, however, restrictions have been placed by law upon this new industry—the law providing in effect that only citizens of Norway may be engaged in the exploitation of these natural water powers. This caused the severance from the Norway enterprise of Dr. Schoenherr, one of the pioneers of this new industry.

The time at my disposal does not permit of enumerating all that has been accomplished in the utilization of industrial wastes through the compelling force of legislation. The aniline industry, the production of sulphate of ammonia from gas residues, of copper as from pickling liquors in steel and wire works, of copper, zinc and nickel from plating works, of fats and soaps from textile mills, and the products obtained in the reduction of garbage would all come under this heading. The last named subject alone is not only of the greatest importance and greatest interest, but in itself would suffice for a complete address.

I believe I have shown that what may at first have seemed oppressive legislation actually developed into progressive legislation, and led to the building up of important chemical industries, which, in point of commercial value, as well as in point of direct benefit to mankind, rank second to none. And now when fears are expressed regarding the commercial and industrial future of this country because of the present tendency to disband large industrial organizations and corporations, I believe the chemist has no cause for apprehension, for it is the chemist, first of all, who is sought in times of need. His services are appreciated all the more when competition calls for a greater exercise of scientific knowledge and of technical skill. This holds good even with respect to the effects of the new tariff. While the removal of a high protective tariff may bring hardships to certain industries, the ingenuity of the chemist and chemical engineer will assert itself and lead us to conditions possibly more equitable than they have been in the past. I believe that it will always be a case of history repeating itself, and I cannot see other than a most hopeful future for the chemical industries of this country.

The Dunn Pulverized Coal Burner

BY G. A. ROUSH

One of the most important improvements in recent years in the manufacture of Portland cement is the introduction of the powdered coal burner in the kilns for the burning of the cement clinker. The wide success of pulverized fuel in this style of furnace has led to numerous attempts to apply it to various metallurgical operations, but without much success until recently. Probably the best known installation for metallurgical work is at the plant of the Canadian Copper Company, Copper Cliff, Ont., where 50 tons of pulverized coal per day are burned in the reverberatory matting furnaces. After an examination of the Copper Cliff installation it has been decided to put powdered coal burners in the reverberatory furnaces of the Anaconda Copper Company, at Anaconda, Mont.

The principle of the pulverized coal burner is, by means of a screw or some other device to feed a continuous stream of powdered coal into a blast of air issuing from a nozzle at high velocity, and then to convey this mixture of coal and air to the furnace, where the coal dust is ignited by the heat radiated to it from the walls of the furnace. The main difficulties encountered are securing a perfectly uniform feed of coal dust, and getting it evently distributed and suspended in the blast of air. These difficulties may result in incomplete combustion or an unnecessary amount of excess air, and "back-flashes." A form of burner that has practically entirely overcome these difficulties has been developed by Mr. William R. Dunn,[1] Superintendent of

[1] U. S. Patents 954,944, Apr. 12, 1910, and 1,028,997, June 11, 1912.

the Vulcanite Portland Cement Company, Vulcanite, N. J. The fact that this burner is now being installed for metallurgical work, and that it has a remarkable applicability both in large and small units, makes it of special interest.

The construction of this burner is shown in Fig. 1. *A* is the feed pipe to the storage bin; *B* is the feed screw; *C* is the mixing chamber; *D* is an air valve; *E* is the air nozzle from the blast pipe *F*, the supply of air from which can be regulated by the gate valve *G*; *H* is the ejector to carry the mixed coal dust and air to the furnace. The important point in the construction of the burner is that, instead of allowing the coal to drop to the air nozzle just as it is fed by the screw, with more or less irregularity due to a slight amount of adhesion of the coal particles, the coal is carried along by the screw and gradually fed out through the perforations in the feed plate, the size of the perforations and the speed of the screw being so regulated that the coal just reaches the end of the perforated plate, for the maximum capacity of the feeder. This method of feeding completely does away with irregularities in the coal supply, and at the same time gives a more uniform suspension of the coal dust by drawing in a portion of the air through the valve *D* by the injector-action of the air jet at *E*, the air thus drawn in mixing with the coal in the chamber *C*, instead of depending, for the entire distribution of the coal dust, on the action of the air jet from *E*. This uniformity of feed and suspension makes it possible to regulate the air supply very closely, so that only a small amount of excess air will be required by the combustion, and entirely does away with the "back-flashes" that result from lack of uniform mixing of the air and coal. By regulating the valves *D* and *G*, the proportion of the total amount of air required that is mixed with the coal in *C* can be controlled, as demanded by the composition of coal, and other conditions of combustion.

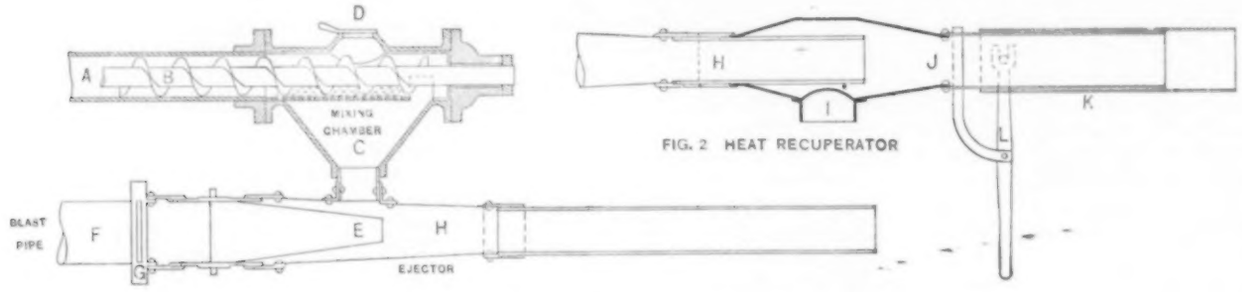


FIG. 2 HEAT RECUPERATOR

FIG. 1 PULVERIZED COAL FEEDER

As applied to the cement kiln, the burner is supplied with the "heat recuperator" shown in Fig. 2. Only about two-thirds of the air required for the combustion is supplied at *D* and *G*, the remainder being drawn in through *I* by the injector-action of the blast of air issuring from the ejector *H*. From *I* a pipe leads to the pit under the kiln into which the hot clinker is discharged, so that the air drawn in is slightly preheated. This of course amounts only to a small saving, but since the cost is no more, it is worth while.

The length of the pipe leading into the kiln can be regulated by the sliding sleeve *K* and the lever *L*. The distance from the kiln wall to the end of the pipe has considerable influence on the shape of the flame.

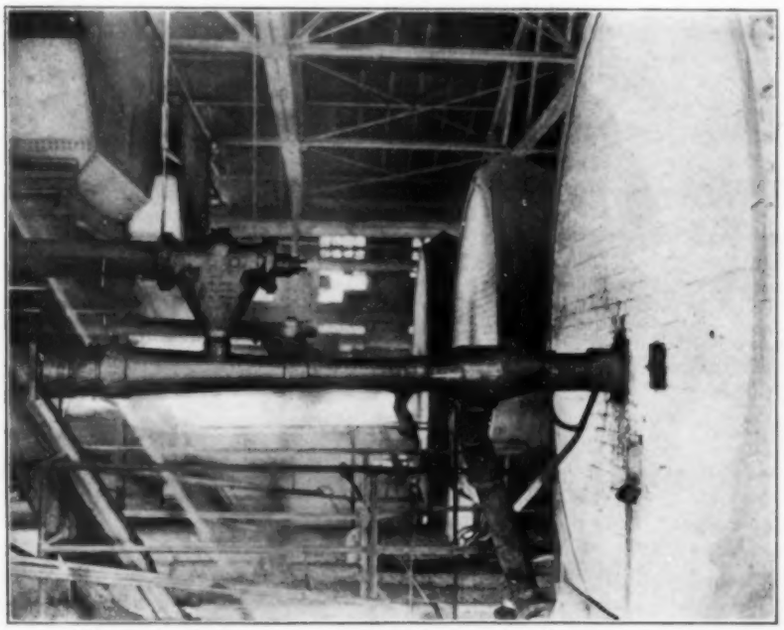


FIG. 3—POWDERED COAL BURNER (CAPACITY 2600 LBS. PER HOUR)

Fig. 3 shows an installation of these burners in the Vulcanite plant, burning 2600 lb. of coal per hour, in kilns 125 ft. long, 7 ft. inside diameter and 8 ft. 6 in. outside diameter, using an air pressure of 8 oz. and a coal, 94 per cent of which passed a 100-mesh sieve. Sixty-foot kilns just beyond these were burning 800 lb. per hour. The flame was about 20 ft. long and the coal ignited at only 4-6 in. from the end of the ejector pipe of the burner. The stack gases left the kiln at 500-550 deg. C. The condition of the end wall of the kiln speaks for itself in regard to the absence of "back-flashes"; these always smut and blacken the wall, but this wall had not been whitewashed for over 30 months.

The substitution of these burners for oil burners in these kilns resulted in a saving of approximately 75 per cent of the fuel cost in calcining, and at the same time, the capacity of the kiln was increased by some 25 per cent.

These burners are working satisfactorily in units as small as 50 and 75 lb. per hour, and it is thought that these smaller sizes can be successfully applied to steam boilers, with a considerable saving of fuel.

Judging from the characteristics and construction of this burner, and from its past record it is probable that other metallurgical applications will soon be developed.

Lehigh University,
South Bethlehem, Pa.

Concentration of Complex Sulphide Ore from the Mary Murphy Mine

BY H. C. PARMELEE

The concentrating mill of the Mary Murphy Gold Mining Co. is situated near Romley, Colo., about 25 miles southwest of Buena Vista, on a branch of the Colorado & Southern Railway. The mines are located in one of the oldest districts in the state, and have been largely productive for 34 years. They were discovered in 1874, and the first extensive work was done in 1879. At various times during the history of the property, reduction plants have been built and operated—an old mill at Romley, and a smelter at Buena Vista. The present mill was built last year and has been in operation since last February.

The mines produce two classes of ore: relatively high-grade gold-silver ore, oxidized and suitable for direct smelting; and low-grade ore containing mixed sulphides of lead, zinc and iron, which must be concentrated and separated into products suitable for lead and zinc smelting.

The valuable metals in the milling ore are gold, silver, lead, zinc and copper, none of which exists in sufficient quantity to make the ore valuable for itself alone. Thus, the assay value of about 4000 tons of ore crushed in September was: gold, 0.25 oz. per ton; silver, 3.1 oz. per ton; zinc, 8.7 per cent; lead, 5.4 per cent (wet); copper, 0.6 per cent. Both mineralogically and physically the ore falls within that class denominated "complex," and the concentration problem is one of securing the best economic recovery rather than the highest metallurgical saving.

A Complex Milling Problem

The complexity of the problem is increased by the physical occurrence of the precious metals and base minerals. The gold occurs free and usually finely disseminated, and the sulphides are generally fine-grained and intimately mixed. The preparation of the ore by crushing and grinding thus becomes the crucial feature of the process. In order to make a high gold recovery the ore should be ground comparatively fine; on the other hand, this procedure entails high loss of the lead and zinc minerals, both of which should be recovered as coarse as possible. Grinding machines that are best suited to the liberation of the gold and silver are inappropriate for the preparation of the base minerals for concentration. The whole problem thus resolves itself into finding and maintaining that happy medium between metallurgical loss and economic recovery of the several metallic constituents, which shall finally result in the greatest net profit for the whole operation.

It has been stated that the gold occurs free and finely disseminated. Metallic gold has never been observed in any of the ore deposits or specimens. Nevertheless a considerable quantity is recognizable by amalgamation; and there is a sporadic occurrence of coarse gold in the ore, for occasionally it is found on the jig screen in nuggets as large as 1/3 in. in diameter.

The methods of concentration employed at the Mary Murphy mill are shown in detail on the accompanying flow-sheet, Fig. 1. In brief, the features of the process are as follows: Coarse concentration begins on jigs, the limiting sizes of the feed being 4.75 mm (3/16 in.) and 1 mm. The portion minus 1 mm is classified for treatment on tables and vanners. The coarsest clean concentrate produced is galena from the hutch of the first compartment of the jig, the screen used being 2 mm. The coarsest tailing discharged is the finer portion of the sand from the table treating the coarsest grade of the minus 1 mm feed. Amalgamated plates and carpets are used for the recovery of free gold and silver.

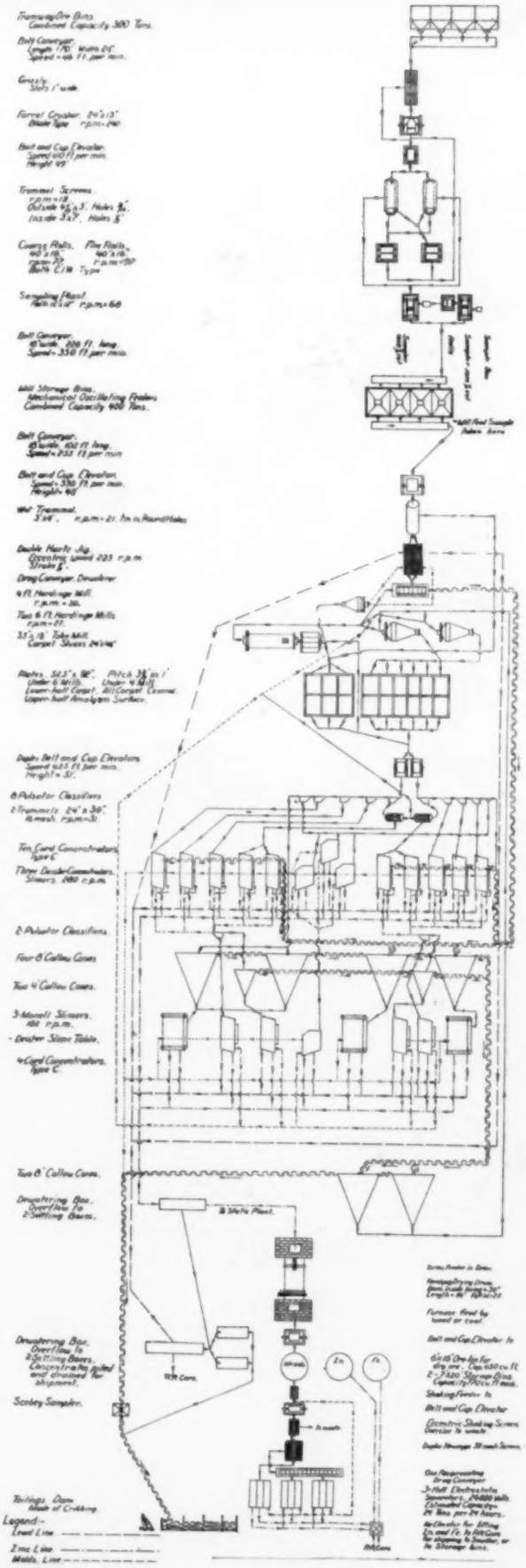


Fig. 1 FLOW SHEET of the MARY MURPHY MILL

Final zinc concentrate is produced only by electrostatic separation of the zinc-iron middlings from the various tables.

Arrangement of Plant

The mill site is located at the mouth of the Golf tunnel, a cross-cut driven before the mill was erected, and which ultimately will be connected with the mine workings and used for the transportation of ore. At present ore is delivered to the mill by aerial tramway. A general view of the mill is shown in Fig. 2, and a view from the opposite side, showing the mill terminal of the tramway, in Fig. 3.

FIG. 2—CONCENTRATING MILL, MARY MURPHY G. M. CO., ROMLEY, CHAFEE CO., COLO.

The concentrating and electrostatic-separating units are separately housed, the latter being in the small building in the foreground of Fig. 2. The lowest floor of the mill is on a level with the top floor of the electrostatic plant, an arrangement which facilitates the handling of the zinc middling produced in the former and treated in the latter.

FIG. 3—VIEW FROM ABOVE MILL SHOWING TRAMWAY TERMINAL

The concentrating machinery in the main mill is arranged on three floors. On the upper floor Card and Deister tables are placed symmetrically on each side of the central duplex wet elevators which deliver pulp to duplicate lines of Richards launder-type pulsator classifiers. A suggestion of this arrangement is given in the flow-sheet, and is shown also in Fig. 7. On the middle floor are Card and Deister tables and Monell vanners, the former retreating middlings from the corresponding tables above, and the latter thickened slime. The bottom floor is devoted to the regrinding machinery, amalgamating plates, and collection and storage of concentrates.

The arrangement of the entire plant permits of flexibility in operation. Storage bins for crude and crushed ore have ample capacity to insure steady operation of the mill without interference from the ordinary delays on the tramway or in the crushing department. The latter is designed in generous proportions, and usually prepares in 8 hours the mill feed for a 24-hour period. The arrangement of the upper and lower table floors in right and left-hand units, in combination with two pulp elevators, makes it possible on occasion to divert temporarily the entire feed to one side or the other.

The regrinding machines, one 4-ft. and two 6-ft. Hardinge mills, and one 3½-ft. by 16-ft. tube mill, have more than sufficient capacity to meet the daily demand, so that, according to a recent change in operation, the small Hardinge can always be kept in reserve. In addition to the convenient arrangement and ample capacity of the machinery, there is plenty of room in the mill for making additions or alterations, and for the storage of concentrates during a part of the winter when railroad transportation is discontinued.

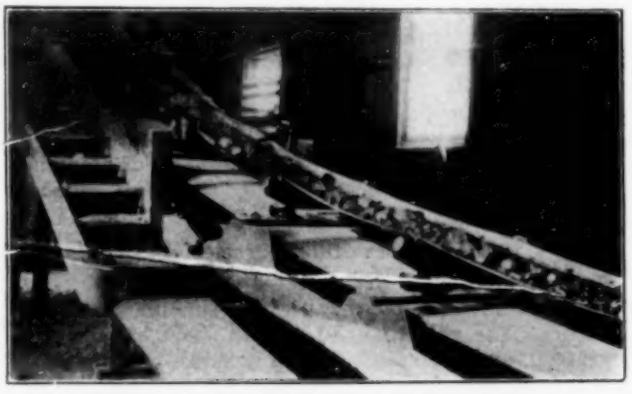


FIG. 4—SORTING BELT BETWEEN CRUDE-ORE BINS AND CRUSHER

Crushing, Grinding and Sampling

Referring to the treatment in greater detail: The ore is conveyed from the crude-ore bins to the grizzly and crushed by means of a belt, shown in Fig. 4. From this belt the final sorting of waste is made, supplementing similar work in the stopes and at the upper tramway terminal. On an average, over one ton of waste per day is sorted out. In September the waste at this point amounted to 36 tons, or 1 per cent of the ore crushed. The main object of the sorting is the elimination of wood, pieces of steel, frozen dynamite, etc.

All of the ore is crushed and rolled to pass a 3/16 in. screen. Crushing and grinding are done dry, but provision is made to run the rolls wet in case the mine ore should become so moist as to stick badly. With wet roll crushing it would be necessary to dewater the product before delivery to the mill storage bins, and for this purpose a drag dewaterer is ready for use when occasion demands. The trommels carry two screens, inner and outer, with ⅝-in. round holes, and 3/16-in. slots respectively. Their oversizes are reground in coarse and fine rolls; the undersize of the outer screen, 3/16-in. (4.75 mm.), is the finished product.

Before delivery to the mill storage bins the ore is sampled. The stream of ground ore falling vertically

from the screens is cut at regular intervals by buckets supported by endless chains traveling horizontally. The first cut is reground in rolls and again sampled in a similar manner, giving finally a sample amounting to 0.1526 per cent of the ore crushed. The reject from the sampler is conveyed to the distributor above the storage bins, shown in Fig. 6.

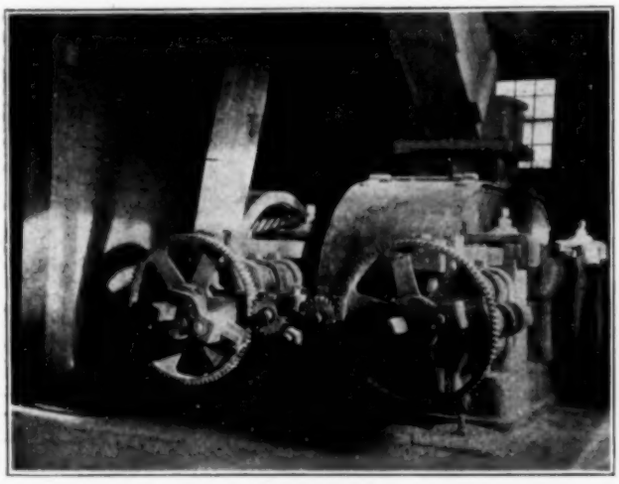


FIG. 5—ONE OF TWO 40-IN. BIG 16-IN. ROLLS, WITH DRY ELEVATOR BETWEEN

The automatic sample represents the metal contents and tonnage of ore crushed and delivered to the mill storage bins each day, but it offers no check on the ore milled during the day on which the sample was taken. The daily mill-feed is hand-sampled every 30 minutes as it leaves the storage bins to enter the concentrating system. Except for the fact that the mill-feed probably is more uniform in value than the mine ore, due to the mixing accomplished during crushing, grinding and distributing, the hand sample is likely to be less reliable than the automatic; and a closer check on the mill work might be obtained through a second automatic sample of the actual daily mill-feed. As far as gold is concerned, however, the tailing for any one day has little relation to the actual feed for that day; a feed temporarily high in gold shows higher gold loss in the tailings for a week or more.

Jigging

Water is added to the ore at the wet trommel, where the split is made between jig and table feeds. The trommel screen has 1 mm round holes; the oversize constitutes the jig feed and the undersize flows first over carpets and thence to the duplex elevators, classifiers and primary tables.

The work of the jig necessarily varies from time to time with the nature of the feed. It is intended to produce a clean galena concentrate from the hutch of the first compartment; zinc-lead-iron middlings from the hutch and side gate of the second compartment; and tailings of quartz and rhodonite still enclosing some mineral. The production of concentrate will occur only when the ore carries comparatively coarse-grained galena; otherwise, when the sulphides are fine-grained and more intimately mixed, middlings will be produced from both compartments.

Both the midding and tailing require regrinding, but in a different degree. The flow-sheet shows the middling flowing to a 4-ft. Hardinge mill, and the tailing distributed among two 6-ft. Hardinge mills and one tube mill.

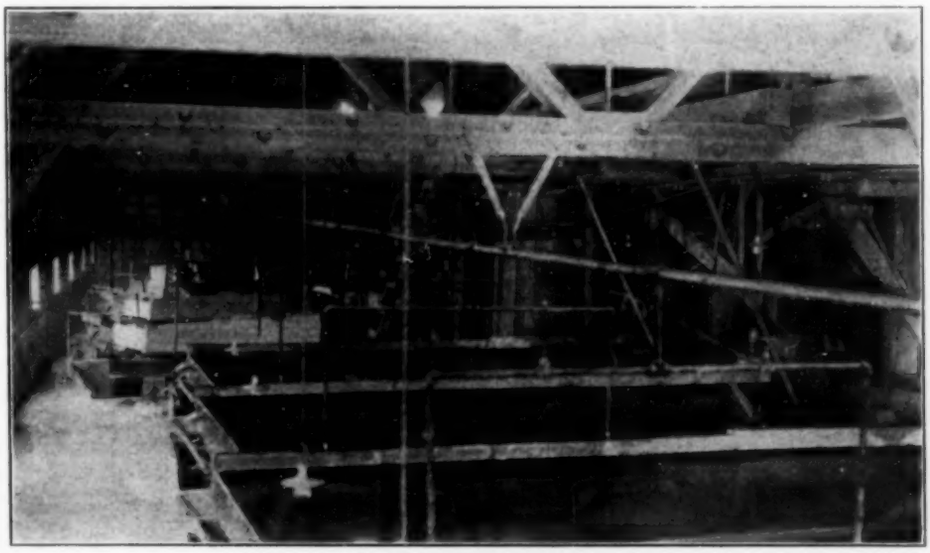


FIG. 7—UPPER TABLE FLOOR. TABLES ARRANGED AT EITHER SIDE OF DUPLEX ELEVATORS IN CENTER

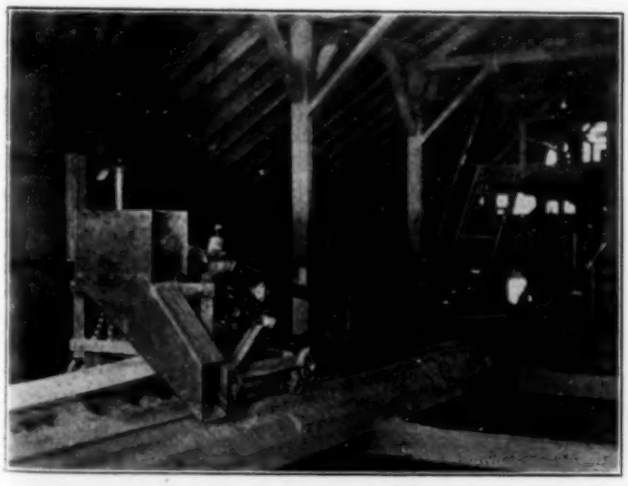


FIG. 6—DISTRIBUTOR ABOVE CRUSHED-ORE BINS

Effect of Regrinding Mills

Experience with the Hardinge mills on this ore indicates that they are satisfactory in regrinding tailings of quartz and rhodonite, but are not so well suited to the regrinding of middlings, as they produce too much mineral slime. For this reason one of the important changes recently made in the treatment is the substitution of a set of 14 in. by 27 in. rolls for the 4-ft. Hardinge mill. These rolls are to be set close, and are expected to accomplish the regrinding of the middling with the production of less slime.

The following figures are fairly typical of the work done in the four regrinding machines. The pulp samples were taken on the same day, with the plant running under normal conditions, treating 125 tons of ore in 24 hours. The screen tests were made on dry pulp. Assays are given in ounces gold and silver per ton, and

per cent of lead and zinc. The desired grade in the discharge lies between —60 + 200.

No. 1 Hardinge, 6-ft., 30 r.p.m. Full load of flint pebbles. Feed: oversize from small trommels in classifier line, in addition to regular proportion of jig trailing. Total 24-hour tonnage, 84.22. Solids, 43.5 per cent; water, 56.5 per cent.

Mesh	%	Gold	Silver	Lead	Zinc
		Feed.			
+ 20	29.69	0.35	2.3	1.79	5.48
+ 40	30.47	0.57	2.0	1.23	5.48
+ 60	16.42	0.62	2.2	1.41	7.51
+ 100	10.93	0.94	3.4	2.07	11.27
+ 200	7.81	0.80	3.5	4.34	13.61
— 200	4.68	0.39	4.5	9.44	13.41
		Discharge.			
+ 40	11.76	0.80	2.3	0.94	3.96
+ 60	21.01	0.59	1.7	1.13	4.77
+ 100	21.85	0.70	2.4	1.70	7.21
+ 200	21.85	0.69	2.7	2.83	9.75
— 200	23.53	0.64	3.1	5.38	9.65

No. 2 Hardinge, 6-ft., 30 r.p.m. Poor grade of grinding pebbles picked up locally. Feed: proportion of jig tailing. Total tonnage in 24 hours, 75.5. Solids, 37.1 per cent; water, 62.9 per cent.

Mesh	%	Gold	Silver	Lead	Zinc
		Feed.			
+ 20	56.31	0.42	2.6	2.07	6.09
+ 40	15.54	0.26	2.7	1.79	8.94
+ 60	6.80	0.47	4.1	2.27	14.42
+ 100	7.75	0.43	3.8	1.89	16.05
+ 200	9.72	0.23	3.1	1.41	13.30
— 200	3.88	0.21	4.7	5.47	25.25
		Discharge.			
+ 40	16.66	0.42	2.2	1.13	3.86
+ 60	14.60	0.52	2.2	1.04	5.58
+ 100	16.66	0.47	2.5	1.32	8.43
+ 200	21.87	0.51	2.6	1.32	11.07
— 200	30.21	0.26	3.6	3.70	11.27

Tube Mill, 3½ ft. by 16 ft., 30 r.p.m. Mixed pebbles. Feed: coarse table middlings in addition to proportion of jig tailing. Total 24-hour tonnage, 129.6. Solids, 30 per cent; water, 70 per cent.

Mesh	%	Gold	Silver	Lead	Zinc
		Feed			
+ 20	60.18	0.23	2.8	1.60	4.67
+ 40	14.10	0.26	2.3	1.51	7.62
+ 60	7.01	0.23	2.7	1.79	16.89
+ 100	8.77	0.36	3.5	1.89	20.05
+ 200	7.60	0.17	2.6	1.32	10.46
— 200	2.34	0.31	5.1	10.58	14.25
		Discharge.			
+ 40	21.18	0.14	1.1	0.85	2.94
+ 60	16.47	0.20	1.4	0.94	6.30
+ 100	23.53	0.29	2.8	1.70	14.86
+ 200	23.53	0.24	2.8	2.07	14.55
— 200	15.29	0.21	3.7	5.85	13.64

Small Hardinge, 4-ft., 30 r.p.m. Mixed pebbles. Discharge end elevated 1¾ in. above the feed. Feed: jig middlings. Total 24-hour tonnage, 142.6. Solids, 18.7 per cent; water, 81.3 per cent.

Mesh	%	Gold	Silver	Lead	Zinc
		Feed.			
+ 20	46.34	0.60	5.2	17.2	33.6
+ 40	12.20	0.64	5.7	16.0	32.4
+ 60	7.32	0.36	4.5	18.7	22.8
+ 100	8.54	0.32	4.3	8.2	17.6
+ 200	14.63	0.26	6.0	9.8	15.0
— 200	10.97	0.28	6.0	16.5	12.3
		Discharge.			
+ 60	2.44	Not enough for assay.		7.5	23.2
+ 100	12.19	1.00	9.0	5.7	22.5
+ 200	34.15	1.24	5.4	11.0	26.5
— 200	51.22	0.68	6.8	8.8	24.3

A noticeable feature of the analyses, particularly in the discharged pulps, is the higher grade of lead and zinc in the fine sizes, and of gold in the coarse. This suggests the possibility of undue loss in the extreme sizes: gold in coarse tailings, and base minerals in slime.

Recovery of Free Gold and Silver

From the flow-sheet it will be seen that the pulp is run over amalgamated plates or carpets, or both, prior to table concentration. The carpet washings are dressed on a table, and the rich concentrate amalgamated in a grinding pan. Another product treated by pan amalgamation is the lead concentrate from the first four riffles of the primary Card tables treating the coarsest pulp. This part of the lead concentrate is very high grade in gold. If mixed with the product shipped to the smelter, it would tend to make sampling more difficult and settlements less satisfactory. Probably it is better to recover this gold as bullion than to run the risks attendant on sampling a "spotty" concentrate.

The following figures show the assay value in ounces per ton of the carpet washings on three consecutive days, and of the concentrate from the first four riffles of the coarse Card tables.

	Gold	Silver
Carpet Washings (a)	10.86	13.5
Carpet Washings (b)	18.50	18.5
Carpet Washings (c)	15.88	18.1
Rich Card Conc.	40.05	38.3

Both Wilton and Brussels carpets have been used for gold recovery, and tests have been made to establish their comparative value as gold-saving devices. Below are given the weights and assay values per ton of carpet concentrates recovered on the two kinds of carpet, under the same conditions of feed for a period of 4 hours. The superiority of Brussels is apparent.

	Weight recovered	Gold Oz.	Silver per ton	Lead per cent.	Zinc per cent.
Wilton	16 oz.	36.2	35.6	35.7	11.2
Brussels	35 oz.	83.8	47.2	48.4	10.5

Table Concentration

Card tables were selected for use in this instance as being better adapted to the treatment of an ore containing several minerals to be separated. Deister slime tables and Monell slime vanners are used on the finest sand and slime pulps respectively. Richards pulsator classifiers of the launder type are used to classify the pulp fed to the tables on the upper floor. The flow-sheet shows similar classifiers ahead of the tables retreating middlings on the second floor; but these are not in use at present, as assays of the tailings from these tables, with and without classified feed, showed no appreciable variation. A further advantage is gained by keeping out of the system the additional water required by these classifiers.

The flow of pulp and disposition of products in this part of the mill can be comprehended better by reference to the flow-sheet than from written description.

Many tests have been made in this department, in an effort to see in what direction improvement could be made. All results seemed to point toward the possibility of an increase in mill capacity without material increase in tailing loss. This has practically been accomplished, and the plant is now treating 150 tons per day instead of the 100 for which it was designed. On one occasion, when one of the duplex wet elevators was being repaired, half of the Card and Monell tables were shut down and the entire feed diverted to the other half, thus doubling the load. This condition prevailed for 12 hours, and the tailing discharged from the mill was not appreciably different from that for the balance of the 24 hours with all tables in use. The assays are given below:

	Gold Oz.	Silver per ton	Lead per cent.	Zinc per cent.
Tailing with all tables running	0.04	1.5	1.2	3.8
Tailings with half of tables running under double load..	0.03	1.2	1.5	4.3

Losses in Various Tailings

The following tabulation of assays on tailings from the tables on the upper floor illustrates a condition already referred to, *viz.*, that the losses of precious and base metals tend to decrease and increase, respectively, the finer the ore is ground:

Table	Classifier spigot	Gold Oz.	Silver per ton	Lead per cent.	Zinc per cent.
2 Cards	1	0.15	1.4	0.7	2.8
1 Card	2	0.11	1.0	0.5	2.1
1 Card	3	0.04	0.7	0.4	2.2
3 Deister	4	0.04	0.7	0.7	2.3
1 Card	Overflow	0.03	1.0	0.7	3.8

This condition is confirmed by many screen tests and assays on the unfinished products from various points in the concentrating system, as well as in the final mill tailing. It complicates the problem of recovery and taxes our known methods of physical concentration almost to the limit. In fact, it is such conditions as exist in this instance that urge some of our metallurgists to seek and hope for successful chemical methods of treatment. The following tabulation on the general mill tailing is added to further show the condition referred to. Assays of gold and silver are in ounces per ton, and lead and zinc in per cent.

Original sample		Gold	Silver	Lead	Zinc
		0.07	2.1	2.4	4.5
Mesh	%				
+ 35	4.99	0.15	2.4	2.1	4.6
+ 65	19.11	0.16	1.5	1.0	3.1
+ 100	10.25	0.22	1.4	0.7	1.7
+ 200	24.93	0.09	1.5	0.8	1.7
— 200	40.72	0.07	3.2	2.9	7.3

Slime Concentration

The commercial value of high-grade products is well shown in the slime concentrates. The flow-sheet indicates that the concentrates from the Monell vanners are split into two products: one which is mainly galena, of sufficiently high grade to be mixed with the regular lead concentrates, and the other a mixture of pyrite, blende and silica. The latter is not a profitable commercial product, as it contains only about 30 per cent zinc and 9 per cent lead. Tests show that this material can be retreated on a Wilfley table, and separated into lead-iron and zinc concentrates which will be more valuable than the original feed. When this plan is put into effect, the Monell table will be operated so as to deliver a more silicious zinc slime, and this will be separated on the Wilfley into (a) lead concentrate, (b) zinc concentrate and (c) tailing which will be returned to the mill system. The Wilfley will be equipped with a wheel for the continuous return of its own middling.

It is by attention to such details as the foregoing that economic success is won in the concentration of complex ores. Products of high commercial value must be sought rather than those which represent primarily the greatest saving. Smelting schedules on base metals, particularly zinc, are so arranged that a difference of only a few per cent in the grade of concentrates will determine the profit or loss on the operation. The Monell zinc slime just considered brings a ridiculously low price in the market, merely because it falls below the grade desired by the smelter. Its commercial value can be considerably increased by redressing it, and the net economic recovery may be increased even though a metallurgical loss be sustained in the operation. Re-treatment of products may complicate the flow-sheet, but is justified as long as more profit can be made.

General Mill Results

The finished products from the concentrating mill are: bullion, lead concentrates from jigs and tables, zinc-iron middlings, and Monell zinc slime. The zinc-iron middlings are treated in the electrostatic plant. Gold and silver occur in all of the mill products, as shown in the following tabulation of results for September. Lead assays are made wet:

	Weight, tons	Gold, oz.	Silver per ton	Lead, per cent.	Zinc, per cent.	Copper, per cent.
Ore crushed	3989	0.25	3.1	5.4	8.7	0.6
Lead concentrate	138	2.26	12.4	48.8	10.8	0.7
Zinc-iron middling	273	0.32	7.0	7.2	38.1	2.3
Zinc slime	34	0.19	7.1	9.6	30.9	1.5
Tailing		0.07	1.7	1.4	4.0	0.3
Amalgam: From pan, 220.6 oz.; from plates, 99.1 oz.						
Saving calculated from heads and tailings		75.9%	50.6%	86.7%	58.6%	55.0%

Tailings Impounded

The mill tailings are impounded in a series of terraced ponds, both because it is an unwise policy in this day to put tailings beyond possible recovery, and because it is necessary to keep them out of the streams. As far as can be seen at present the tailings have no value, but if metallurgical methods should become sufficiently improved to treat such material profitably, it will be available without great expense. Possibly when that time arrives the successful method can be applied to the crude ore with better success than now attends concentration.

Electrostatic Separation

The Huff electrostatic system[1] is used for the separation of the zinc-iron middling into merchantable products for zinc and lead smelting. The equipment and general arrangement of the plant are shown on the flow-sheet. The capacity is approximately one ton per hour, except on a slime feed, when it falls about one-half. The ore is first dried in a wood-fired rotary kiln,

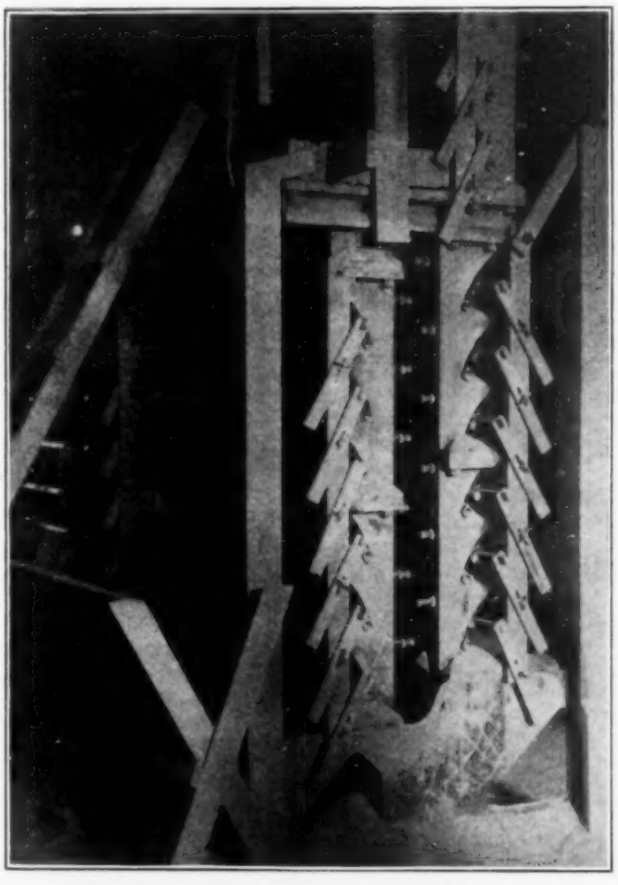


FIG. 8.—PORTION OF ELECTROSTATIC SEPARATORS

consuming one cord of wood per day. The drier is lined with fire-brick. Some difficulty has been experienced in keeping the lining intact, but recently this trouble has been overcome by setting the brick in a mortar of cement and asbestos.

The dried pulp is separated into coarse and fine grades by a Newaygo 50-mesh screen, and the plus and minus sizes are delivered to the three Huff separators. These are of the "toboggan" type, shown in part in Fig. 8. The upper set of electrodes give a rough separation of iron from zinc, and each of these products is finished on one of the two lower sets.

A middling product results from the final separation, which requires further treatment. Several methods of handling this material have been experimented with: it has been added continuously to the original feed, and

[1]Descriptions of this process have appeared in this journal, May, 1910, p. 295; Nov., 1910, p. 636; Jan., 1912, p. 49; Oct., 1913, p. 581.

it has been accumulated and treated separately. The latter method results in a further complication: a second middling is produced which, for a curious and unexplained reason, refuses to yield a further separation either by electrostatic treatment or wet dressing. The result is a final accumulation of a comparatively worthless product.

The opinion generally maintained on the retreatment of electrostatic middling is that it should be added continuously to original feed, and this method may be finally adopted at this plant.

The flow-sheet shows electrostatic treatment of the zinc slime from the Monell vanners. The greatly reduced capacity of the electrostatic separators on this fine material, combined with the unsatisfactory results

FIG. 9.—SLIME SETTLING PONDS

obtained in regard to grade of product, has led to the discontinuance of this practice.

As stated before, an effort will be made to beneficiate the Monell slime by a retreatment on a Wilfley table.

The following results are typical of the electrostatic work done on different feeds:

Table Middlings.

	Gold	Silver	Lead	Zinc	Copper	Iron
Feed	0.40	6.8	7.2	35.9	2.6	10.8
Zinc product	0.40	5.2	5.6	47.2	0.9	5.2
Iron product	0.41	8.6	9.8	15.2	5.1	24.2
Feed	0.42	6.4	7.6	37.8	1.3	10.7
Zinc product	0.24	5.1	5.0	51.8	0.6	3.8
Iron product	0.52	9.1	10.3	17.8	2.5	23.0

Retreatment of Electrostatic Middlings.

	Gold	Silver	Lead	Zinc	Copper	Iron
Feed	0.52	9.1	10.2	28.2	1.4	14.0
Zinc product	0.56	9.8	11.1	34.8	0.7	9.4
Iron product	0.62	9.9	9.0	12.8	5.0	26.8

Monell Zinc Slime.

	Gold	Silver	Lead	Zinc	Copper	Iron
Feed	0.22	6.8	8.8	31.0	1.6	10.0
Zinc product	0.34	6.1	11.9	34.2	1.6	8.5
Iron product	0.52	10.0	8.7	16.4	5.0	22.4

The dust formed in the process of drying the middlings appears to be inconsiderable, amounting to only two tons in four months. Ninety-two per cent of it is finer than 200-mesh.

It assays 0.32 oz. gold and 9.9 oz. silver per ton, 8.0 per cent lead, 24.5 per cent zinc, 3.9 per cent copper and 8.5 per cent iron.

It is practically without commercial value, and would be a difficult material to treat by wet or dry methods of concentration.

In conclusion the writer wishes to express his appreciation of the courtesy of Mr. George E. Collins, general manager, and members of his staff, for the facilities offered in collecting these notes.

Chemistry of Salt Water Cement

Notes on Sand, Stone and Gravel

BY HARRISON S. TAFT

1. The success to be attained by placing concrete structures in sea water depends upon, first, the possibility of using cement in salt water, and, second, an economical design. Without doubt a great many prominent engineers hesitate to recommend the placing of concrete structures in sea water more from a chemical point of view perhaps than from a structural one. If the material out of which the structure is to be built cannot be depended upon to maintain its integrity when exposed to the elements, the very best design will not solve the problem.

Therefore the chemistry and manufacturing side of the cement industry becomes a question of prime and vital importance as regards cement to be used in sea water structures. The next question is that of impermeability; otherwise the concrete might slowly deteriorate under the action of the chemicals in sea water, since perhaps it is impossible to reduce such actions to a negative quantity. In freezing climates this question of impermeability becomes a very serious one, due to the destructive action of alternate freezing and thawing.

2. **Cement.**—The first and chief difficulty that has to be overcome in using concrete in sea water is "the peculiar chemical disintegrating action of the magnesium and other sulphate contents of ocean water upon the alumina compounds in the cement," followed "by the abrasive action of the water of the ever-restless sea" upon the chemically affected and softened concrete.

To overcome the chemical action of the sea water upon concrete the Germans have placed upon the market a brand of cement called "iron ore cement," wherein the alumina content of a cement is partly replaced for fluxing purposes by iron which is not affected deleteriously by the magnesium and other sulphates of the salt water; thus inoculating the concrete, as it were, against attack. The world-famed Teil Cement Works does not allow more than 2 per cent alumina and absolutely no free lime in the cement which they manufacture for use in concrete structures standing in sea water.

Another German product called Puzzolan-Portland Cement, especially devised for use in sea water, has been on the market some 16 to 18 years. This product is a mixture of Portland cement and a natural puzzolan (a volcanic ash), or of a Portland cement and an artificial puzzolan (blast furnace slag of a certain chemical composition), the mixture being 30 to 60 per cent puzzolan and 50 to 70 per cent Portland cement.

The chemical action in hardening results in a Puzzolan-Portland hydraulic cement invulnerable to sea water. Although the mixing can be done on the job, it is far preferable to pulverize the two ingredients together in the mill at the cement factory.

A set of extensive tests made by the German government shows higher strength for Puzzolan-Portland cement concrete both in tension and compression than for pure Portland cement concrete. It has also been demonstrated that the former resists salt water far better than the latter. From an economic point of view in producing resistance to the action of sea water a barrel of Puzzolan-Portland cement has been found to be equal to two barrels of pure Portland cement.

From information obtained in regard to these two German cement products, concrete made of them and placed in salt water has been giving the best and most satisfactory results. Thus a vast amount of salt water concrete construction is being carried on in Germany and other foreign countries, due no doubt to their overcoming the action between salt water and the cement.

Though there have been a number of disastrous disintegrations in using American Portland cements in salt water, on the whole American Portland cement seems to have worked quite satisfactorily in sea water.

Such cement "has the power of armoring itself against the action of the magnesium sulphates of the sea water by the formation on its exposed surfaces of a film of lime carbonate." This film appears to serve as an effective protection to the concrete structure in comparatively still waters, but where the waters are greatly agitated this film has no opportunity to form. Hence "the calcium hydrate set free by the decomposition incident to the hardening of the Portland cement is washed away," leaving the concrete stucture unprotected against "further inroads of the deleterious chemicals contained in the sea water."

To reduce the question of the chemistry of sea water cement to a more technical form:[1] "The magnesium sulphate present in sea water acts upon the calcium hydrate of the cement, forming calcium sulphate, and further, this calcium sulphate combines with the alumina of the cement, forming calcium sulpho-aluminate, which last compound gives rise to the swelling and cracking of the concrete."

Mr. O'Hara also states that though it may seem that a cement in which the alumina has been replaced by iron is desirable, it would be impracticable, however, to replace *all* the alumina in a cement by iron oxide, as "a product resulting from the burning of ferric oxide and calcium carbonate does not possess hydraulic properties." He further says that whereas it seems to be universally accepted by engineers and others that a dense concrete is impermeable to sea water, the results of tests made by him do not seem to bear out this theory, unless the cement used has the inherent qualities to resist the disintegrating action of the sea water.

In discussing the subject of mass concrete in block form for breakwater purposes, William Matthews, a prominent English engineer, says:

"In a tideway, where mass concrete is used, it is of the utmost importance that the relative sizes and proportions of the aggregate should be such as to produce an absolutely water-tight material. The infiltration of sea water into green or unset concrete and its subsequent exudation due to tidal action causes the magnesium salts in the sea water to withdraw a portion of the lime of the cement in the form of calcium salts, leaving a deposit of magnesia in its place. It is this magnesia, derived from sea water, either alone or mixed with lime from the cement, which constitutes the white substance deposited in the interstices of porous concrete between high and low water. Concrete so affected possesses but little strength and its failure is only a question of time."

As the result of his research upon the use of cement for sea water purposes, the eminent Dutch chemist, V. I. P. de Blocq van Kuffeler, Hoorn, states[2] "that the decomposition of the concrete is caused by the salts contained in sea water; the sulphates are the most to be feared owing to their action on the unstable compounds of lime which are formed during the very long period taken by the cement for hardening. Evidently it is during the first part of this period that the action of sea water is the most detrimental, i.e. when the compounds are least stable. Actual experience has confirmed this theory."

He also says that "when such material as trass or puzzolanes are added to the cement, one part of the lime forms compounds with silicates, the other compounds mentioned becoming more stable and the influence of sea water is less to be feared"; that "fine trass increases the impermeability of the mortar"; and "if the concrete has been hardened in a damp atmosphere the influence of the trass is still more marked."

Irrespective of the brand, a cement to be successfully used in salt water must be of the very best quality, of a fine pulverization, and thoroughly analyzed and tested for its chemical properties. Every means should be taken to avoid too much alumina in a cement that is to be used in salt water. The per cent of alumina should be low, that of silica high. The cement should also be as free as possible from gypsum.

A cement of the slow hardening order should be avoided. Distinction between "setting" and "hardening" of cement should be kept in mind. A slow setting but quick hardening cement is the proper kind to use in salt water.

Not only must the cement manufacturers provide the engineer and the contractor with a cement of the proper chemical constituents, but the concrete made from said cement must be dense in order to fulfill all the requirements of a salt water concrete. This apparently is what the Germans have been doing, and it explains why they are able to get such excellent results in concrete work in Germany as well as in other foreign countries. It is an exceedingly important question for domestic cement manufacturers to consider.

As considerable stress has been laid above on the German method of manufacturing cement for sea water purposes, it is fitting to still further consider what Herr Blocq van Kuffeler says upon the question of using cement in concrete placed in salt water. He states that the following points should be most strictly adhered to in using concrete in salt water:

(a) Artificial (slow-setting Portland) cement of first-class quality and hardening very uniformly, should be used to the exclusion of all others.

(b) The mixing of the material and the ramming of the concrete in strong and tight casings must be performed with the greatest possible care.

(c) The use of trass (or puzzolanes) is recommended.

(d) The concrete must be compact and the composition of the mortar should not be below 1 part cement, ½ trass and 3 sand, or I part cement, 1½ sand.

(e) Allowing the concrete to set in a damp atmosphere before placing "in situ" greatly increases its resistance to attack by sea water and is recommended where possible. When the concrete is exposed to the infiltrations of sea water immediately after manufacturing its composition should be richer.

In conclusion he says a carefully considered composition, most careful manufacture, the use of excellent cement with trass (or puzzolan) and hardening in a damp atmosphere are the most efficient means of satisfactorily ensuring the preservation of reinforced concrete in maritime works.

3. Laboratory or Similar Tests.—For several years past the United States Government has been carrying on a set of tests at Atlantic City and elsewhere to determine the exact fact as regards the use of cement in sea water. A preliminary report of these tests has recently been issued by the Government. Although three years is a comparatively short time for determining the absolute facts under actual conditions, the results of these tests so far published seem to indicate that the success of using concrete in sea water depends in a large degree upon careful and proper working of the material rather than upon the special brand of the cement itself. It is true that some cement works better than others in sea water, those with a low percentage of alumina giving the most satisfactory results, but with an impermeable structure as the prime factor in all cases.

Although these Government tests will no doubt in

[1] From Report of J. M. O'Hara, Southern Pacific Railway.
[2] From a paper read before International Association for Testing Materials, New York, September, 1912.

time give the concrete engineer the absolute facts as regards the situation, the engineers of this country already have the actual experience of some 18 years of foreign practice by which to guide themselves. No doubt the final results of these United States Government tests will simply substantiate what has already been learned regarding the use of cement in sea water by foreign chemists, viz.: an *impermeable mass* with a low per cent of alumina in the cement used.

In the early part of 1909 twenty-four test pieces were made of concrete and hung from one of the wharves at the Charlestown Navy Yard, Boston Harbor. These test pieces were 16 feet long, 16 inches square and made with a core for part of their length so as to provide a means of determing their permeability. Several different kinds of cement were used in making these pieces and the concrete mixed in various proportions; some of the pieces being made dense, others porous. These pieces were hung from the pier in such a way as to have their lower ends always in water, while the tops were seldom submerged. At the end of the first two years of immersion one of these test pieces showed marked signs of deterioration, while others were in good condition. Later reports go to substantiate the truism mentioned above, since the pieces made of a porous nature have deteriorated somewhat while those of a dense nature are in the same perfect condition as the day they were made.

Though these laboratory tests will go a long way in revealing the true facts and actual conditions it is necessary to guard against in the use of cement in sea water, "it must ever be kept in mind that the phenomena, both physical and chemical, in the sea cannot be reproduced exactly in laboratories on land." Consequently laboratory tests will never give the real truths of using cement, and hence concrete, in sea water as will actual experience. Thus the actual experience of foreign engineers in the use of concrete in sea water structures and the modes pursued by them are far more valuable to the American engineer than any short time test made in this country.

Admitting that laboratory tests are absolutely necessary and that the world cannot get along without them, such tests must be considered hand in hand with actual experience and as supplementary thereto. The fact that local conditions and local material will seriously alter cases brings home to the engineer the truth that he must not judge foreign experience by home conditions, and vice versa, until the actual conditions covering each are known and is used as the complement of the other.

4. Waterproofing Compounds.—In view of the claims made by waterproofing experts as respects the excellency of their product, it is proper to quote from an article entitled "Test of Water-Proofing Material," U. S. Bureau of Standards, No. 3, August 22, 1911: "Portland cement mortar and concrete can be made practically water-tight or impermeable (as defined below) to any hydrostatic head up to 40 feet, without the use of any so-called 'integral' water-proofing material; but in order to obtain such impermeable mortar or concrete, considerable care should be exercised in selecting good material and aggregate, and proportioning them in such a manner as to obtain a dense mixture. The consistency of the mixture should be wet enough so that it can be puddled, the particles flowing into position without tamping. The mixture should be well spaded against the forms when placed so as to avoid a formation of pockets on the surface."

"The addition of so-called 'integral' waterproofing compounds will not compensate for lean mixtures, nor for poor material, nor for poor workmanship in the fabrication of the concrete. Since in practice the inert integral compounds (acting simply as void filling material[1] OR IN THE NATURE OF A LUBRICATING MATERIAL) are added in such small quantities, they have little or no effect on the permeability of the concrete. If the same care is taken to make the concrete impermeable, without the addition of waterproofing material, as is ordinarily taken when waterproofing materials are added, an impermeable concrete can be obtained."

In connection with this part of the subject it may not be out of place to speak of "oiled concrete" for waterproofing certain classes of concrete structures. It is of such recent development that sufficient opportunity has not been given to determine its real merits for universal waterproofing purposes especially as regard concrete structures standing in sea water. So far as known there are no records "of any such tests ever having been made" and some chemists have positively stated that it will be impossible to make oiled concrete a success for sea water purposes.

On the other hand, F. Hiroi, a civil engineer of Japan, has stated: "Of more than 12,000 concrete blocks of all sizes and of different compositions, used by the writer in harbor works during the past ten years, there has not been the slightest indication of failure. On the contrary, the protection given by coatings of animal, vegetable and mineral origin to the surfaces of the blocks has rendered them almost impregnable against the incessant action of the sea. The protection thus afforded by nature, which would render a comparatively weak artificial stone, when properly made, as lasting as the natural stone used as its ingredient, is unknown in laboratory experiments."

5. Sand, Gravel, Stone.—The sand used in concrete placed in sea water must be clean, sharp and free from all foreign material. The stone must also be clean and sound. Gravel, if used, must likewise be clean and of proper size. The chemical composition and mineral structure of the stone, sand and gravel for use in proposed sea water concrete structures, should be known absolutely beyond all doubt. Since it is of great importance that concrete used in sea water should have the maximum density, the mechanical composition of sand and gravel should be known and modified, if necessary, by adding screened material.

For the same reason that an igneous rock or material is far better in the construction of a fireproof concrete structure, it is absolutely necessary in salt water concrete to use aggregates that will not disintegrate or fail when exposed to the elements of the salt water and the action of the sea.

The eminent expert, Mr. John R. Freeman, has called the attention of engineers to the fact that "here and there are banks of sand and gravel which, upon ordinary inspection, appear ideally perfect for making mortar and concrete, but which are nevertheless dangerous in the extreme, and all because of some ultramicroscopic content, probably similar to tannic acid (in a colloidal film around the sand grain), which works in some mysterious way to prevent the union between the cement and the sand grains."

Mr. Freeman cites an occasion where he found the site of a proposed structure what promised to be a most economical resource in a shape of excellent sand and gravel; but upon being tested some of the samples of 1:3 mix, six days in water, hardly maintained their integrity while being placed in the clamps and before any load was applied. The cement was of a brand that had given excellent results with other aggregates.

E. E. Free, an investigator, engaged upon physical and chemical investigations for the Bureau of Soils, has noticed analogous phenomena in studying the relative fertility of different soils. Mr. Free states that:

[1] The portion in capital letters inserted by writer.

"In popular terms the situation can perhaps best be explained by considering that an extremely thin film of a complex form of tannic acid surrounds each grain of the troublesome sand and prevents its attachment to the cement. These complex organic acids have a strong tendency to spread themselves thinly and strongly adherent over the outside of the siliceous material. The reason why one particular brand of cement is able to break through this filmy barrier so as to get a firm grip upon the sand grain is because of its containing a small quantity of some form of alkali that unites with this acid film or somehow changes its colloidal state."

It is admitted that these defective sands are the exception rather than the rule. Though some engineers and contractors may think the whole investigation a highly interesting laboratory amusement, of no value whatsoever to practical construction, the fact remains that there are sands whose availability for concrete aggregate cannot be predicted under any of the ordinary methods now in vogue, and that every so often one of these sands gets into a structure to its detriment and perhaps failure if the structure stands in sea water. Therefore the sand and stone should be tested as carefully as the cement for salt water purposes.

Of equal importance is the utmost care that must be taken in mixing and placing the concrete, in order to obtain an impermeable mass throughout. Superintendents and concrete foremen should also be careful to see that injurious acids do not get into the sand, gravel and stone of concrete to be placed in sea water by the working force urinating upon the material.[4] Great care should likewise be taken to exclude from all material entering into the manufacture of concrete such things as scraps from lunches, tobacco and the spittle of those chewing tobacco. It is known that an amount of sugar, even as small as ¼ per cent will entirely prevent a batch of cement from hardening. Since the extract from chewing tobacco contains sugar or glucose, any such extract that enters into the concrete will prevent the cement from setting. There are other organic compounds whose presence in the concrete will have a marked effect on the hardening of the cement, and the utmost means should be taken to exclude such detrimental material from all concrete to be placed in sea water.

6. Mixture.—In connection with the concrete dock work of the Thames River the practice seems to have been to use "a gravel of moderate size combined with two-thirds of its bulk of sand mixed with one part of cement to every two parts of sand," viz., a 1-2-3 mixture. It is stated that with such a mixture there will be no fear of the results if the concrete is *properly mixed and handled*. The concrete is also given a grout coating after it has set and hardened.

In building concrete breakwaters in Holland it has been found that mass concrete blocks made of 1 part Portland cement, ½ part trass (the trass being a Puzzoland which is found near Andernach on the Rhine), 3 parts sand and 5 parts Rhine gravel, enabled the blocks to resist the corroding action of the sea water. Of more recent date they have been using a cement-trass-concrete of 1 part cement, 1-3 part trass, 2 parts sand and 3 2-3 parts gravel.

In Germany a mixture of 1 part cement, ½ part trass, 3 parts sand, 4 parts gravel, is very often used.

During recent years a very rich mixture, viz., 1-1½-3, has been used in nearly all the important sea water concrete structures built in England and France.

In the harbor development of Otaru, Japan, a proportion of 1 part cement to 2 parts sand for the mortar gave superior results; the average concrete mixture used being "1 cement, 2 sand, 2 gravel and 2 broken stone, before the tuff was put in; the ratio equivalent by weight of the cement to the tuff being, 1 cement to ½ tuff." By volume this combination reduces to:

1.0 cement; 0.8 tuff; 3.2 sand; 6.4 ballast.

In the Netherlands Portland cement concrete with the addition of trass has been used almost exclusively. Though Herr Blocq van Kuffeler recommends a mortar of 1 part cement, ½ part trass and 3 parts sand mixture for sea water structures, he states that concrete of the above composition will remain in a perfect state of preservation "provided it has been hardened in a damp atmosphere before placing *in situ*, but is apt to give disappointment if the concrete is exposed to the infiltration of the sea water immediately following manufacture." Under the latter conditions he recommends a richer composition—at least 1 part cement, ½ part trass, 2½ parts sand. When no trass is used he says a mixture of 1 part cement, 1½ parts sand should be used. He also says that whereas mortars of 1 cement, 1½ sand and of 1 cement, 1½ trass, 3 sand can be used with safety in marine concrete work, the latter will create a saving in cost of considerable extent. It is also of great importance that the cement and the trass should be thoroughly mixed before the sand is added.

As respects the use of salt water in the manufacture of concrete, the same eminent chemist states that since the amount of salts introduced into the concrete by diffusion when the concrete is exposed to sea water is vastly in excess of any salts that might be introduced into the concrete "by the small quantity of water used in its manufacture—the use of salt water in the making of concrete is in all probability prejudicial to only a slight extent."

As in ordinary reinforcement work, when the reinforcement is complicated, a smaller size gravel should be used with their homogeneity increased, a size of not over .116 cubic inch being recommended by a leading authority for marine reinforced concrete.

Mr. I. W. Sandeman, in his paper upon "Action of Salt Water Upon Concrete," states that for salt water purposes the maximum proportion of the sand in the mortar must not be more than twice that of the cement, and the mortar must exceed the voids in the aggregate. The exact grade of the sand mixed with the cement plays an important part in obtaining impermeable concrete, a hard, coarse sand giving the best results. It was the knowledge of this important point and a thorough investigation of it that enabled the noted Italian engineer, Com. Luigi Luiggi, to construct a dry dock at Bahia Blanca, in 1902, that resulted in a perfectly water-tight job. The utmost care was taken in the construction of this dock, with special attention to the bonding of old concrete to the new.

As respects the advantages of using crushed stone over gravel, Mr. Staniford, chief engineer of the New York Dock and Ferry Department, states that his department does not find gravel a suitable material to use in mass concrete when subject to the action of sea water, and that the broken, hard trap rock, so commonly used in New York City and vicinity, gives far better results in such kinds of concrete than are obtained with gravel. From the author's own experience with broken stone and gravel, he prefers stone, especially if it is trap rock.

7. Conclusion.—In the final analysis, the successful use of cement in concrete structures standing in sea water boils down to the use of an impermeable concrete made of a cement low in alumina and otherwise suit-

[4] Notes from a paper to be published by Chas. A. Newhall. By permission.

able for salt water purposes. The former is the problem of the concrete and construction engineer; the latter the problem of the chemist and cement manufacturer. To obtain an impermeable concrete a very rich mixture must be used, the exact proportion between the finer and coarser material being dependent upon the per cent of voids.

If possible the concrete should be hardened in a damp atmosphere in order to assist the chemical reaction of setting before being placed *in situ*, or before being subject to the action of the sea water, especially so if the sections are small.

The mixing and placing should be closely watched and done with the greatest care, far more so than in the ordinary building work, in order to ensure that each particle of the sand and coarser material is well covered with cement and mortar respectively. A concrete of a medium or plastic consistency will ensure far better results than a wet or dry mixture.

"In the Netherlands experience has furnished conclusive examples as a guide for future construction, with a sufficient degree of safety, as to justify the further application of reinforced concrete in marine structures, which after all are only the work of mortals and not destined to last for eternity."

Seattle, Washington.

Color Photography Applied to the Demonstration of the Microstructure of Ores

Mr. Gilbert Rigg, research engineer of the New Jersey Zinc Company, presented at the meeting of the New York section of the American Electrochemical Society, on October 17, 1913, a brief but exceedingly interesting lecture on the application of color photography to the elucidation of ore structure.

As mentioned in our report of this meeting in our November, 1913, issue (page 622), Mr. Rigg has been the first to apply color photography for this purpose. At that meeting he exhibited a striking series of Lumiere plates showing photomicrographs of ores, with resolution of the minerals present. While for mechanical reasons it is impossible for us to reproduce here these pictures, we are glad to give herewith an outline of Mr. Rigg's remarks made in connection with his demonstration.

While microscopic examination of thin slices of ores furnishes valuable indications as to their structure and to their probable behavior in the mill, this method requires the services of a man trained in the work. To get the results in such form that they can be readily understood and appreciated by the mill engineer and the mill foreman has not been an easy matter.

Plain microphotographs, depending only on differences of light and shade, are not easy to interpret by men not familiar with microscopic investigation, and in many cases the presence of a competent expert, provided with suitable equipment, is out of the question.

The Lumiere plate provides a means by which the indications of the microscope can be reproduced in their natural colors. Such matters as the fineness of the constituents of the ore, the shape of the different minerals, the manner in which they are interlocked, the nature of the gangue minerals and other particulars having a direct bearing on the problem of concentration, can be brought out in a manner which is both striking and instructive.

The slides shown by Mr. Rigg were intended to illustrate certain associations of minerals which are of importance as affecting the recovery in concentration.

Adhesion of valuable minerals to the gangue was shown by a slide representing a mica-schist carrying thin, wedge-shaped particles of blende and chalcopyrite intercalated between the plates of mica. On crushing, the valuable sulphides remained attached to the plates of mica and were carried by them into the tailings.

Losses due to parasitic inclusions were illustrated by a slice of actinolite rock, carrying blende as an interstitial mineral between the actinolite crystals, and quite capable of recovery, and also as parasitic crystals inside the actinolite crystals, and therefore destined to accompany the latter into the gangue.

An example of trouble due to fineness of grain was shown by a slide of calcite, permeated by hair-cracks and fine fissures filled with blende. The difference between the assay and the mill recovery with an ore of this type would be very great.

The application of polarized light to the demonstration of the constituents of an ore was illustrated by two slides of a calcite-willemite ore, one taken in ordinary light and the other in polarized light. The former simply showed an aggregate of colorless crystalline grains. The latter showed the calcite as various shades of grey, and the willemite in brilliant blues and pinks.

The contrast between examination of a hand specimen by the unaided eye and the indications of the microscope was shown by a specimen of argentite.

The hand specimen appeared to be solid argentite. The microscope showed a series of fine lamellæ of argentite and quartz. An ore of this kind would give a disappointing assay.

Copper-Rich Kalchoids

A word unusual in scientific nomenclature is used by Prof. Samuel L. Hoyt in the title of his paper "On the Copper-Rich Kalchoids," read at the recent meeting of the British Institute of Metals. But kalchoids is a useful "omnibus" word, being employed to designate the ternary alloys of copper, tin and zinc as was first suggested by Thurston, and as such its use should extend.

In the paper under discussion Professor Hoyt gives the results of a prolonged research into the constitution of certain kalchoids rich in copper, the percentage of zinc and of tin never exceeding 50 and 30 respectively. From his microscopical analyses—and the paper is very liberally illustrated with upwards of 40 photo-micrographs in plate form—Professor Hoyt draws the general conclusion that the ternary alloys of copper-tin-zinc, up to the above-mentioned percentages, behave similarly to the binary alloys of copper-tin and copper-zinc. The liquidous surfaces, the limit of saturation of the alpha solid solution and the eutectoid line have been determined. The eutectoid surface was found to have a maximum near the middle corresponding to 66 per cent copper, 17 per cent tin, 17 per cent zinc and 590 deg. C. on the eutectoid line. This line showed the beta solid solutions to be isomorphous. Quenching from this line produced homogeneous solid solutions. The addition of tin to the copper-zinc alloys, or brasses, caused the visible breakdown of the beta solid solution. The amount of the tin necessary varied with the zinc content and with the rate of cooling through the critical range, thereby giving rise to abnormalities in the microstructure which are explained and well illustrated in the paper. An interesting point is that Professor Hoyt records the finding of a field off the alpha plus beta range in the bronzes in which two heating effects in the solid were observed.

The research is also noteworthy as showing the world-wide interest in the work of the (British) Institute of Metals, seeing that the paper has been prepared by a professor in the American University of Minnesota, who made his investigations in the Charlottenburg-Berlin Institute of Technology.

A New High-Temperature Furnace

BY EDWIN F. NORTHRUP

For over two and a half years the writer has been conducting an experimental research upon the electrical conductivity of matter over a wide range of temperature above 0 deg. C. He early learned that the limit of his upper temperatures was greatly restricted if any furnace upon the market was to be used. It is true that

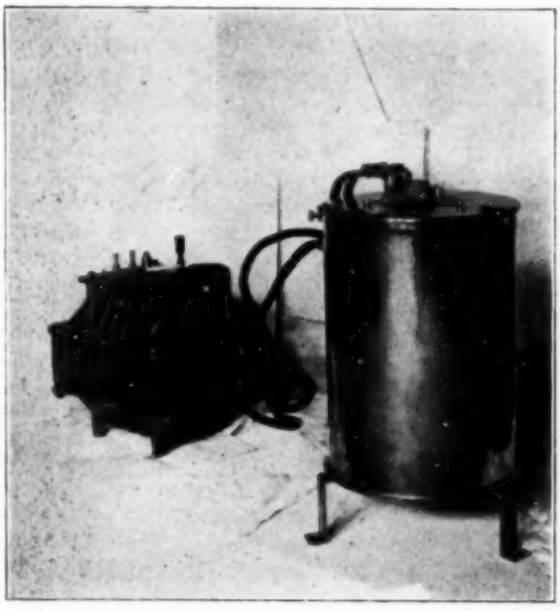


FIG. 1.—FURNACE AND TRANSFORMER

vacuum furnaces of the Arsem type give as high temperatures as may be needed. But for the work in hand a very large furnace of this kind would be required to give a temperature of the necessary uniformity over a considerable length of the tubular space, and, furthermore, the difficulties in the way of feeding metal into the furnace and of bringing many leads out of a vacuum furnace were not easy to surmount. Furnaces operated with a hydrogen atmosphere to preserve the molybdenum or tungsten wire used as a winding from oxidation are unsuitable because hydrogen acts upon many of the molten metals. He was obliged, therefore, to develop a new and special type of furnace for the satisfactory prosecution of his research. This new type of furnace has had a development which has lasted over six months and it is now in a highly satisfactory state.

It is a laboratory furnace of the tubular type and is required to meet, in a very perfect way, the following conditions:

It must give a very uniform temperature in a tubular space about 12 in. long by 1⅞ in. in diameter.

The furnace must run for several hours above the melting point of platinum (1755 deg. C.) without being rapidly deteriorated.

The hot tubular zone must develop a pure CO atmosphere and the heating unit not be injured by the vapors of any molten metal or other material placed in the tubular space.

It is desirable and almost essential that all parts of the furnace, including the heating unit, should be quickly and easily replaceable. The life of the heating unit should be such that the expense for new heating units is not excessive.

It is evident that the one material for a heating unit which gives most promise of meeting these conditions is some form of carbon. The form of carbon adopted is pure Acheson graphite. This material has a low though very constant resistivity. As pointed out in a former article* its resistivity decreases about 9 or 10 per cent in the temperature range 20 deg. to 1500 deg. C. and not rapidly thereafter. There is probably no other material that has so constant a resistivity over so great a range of temperature. The resistivity being low, it is evident that the current must travel through a long length of the material and through a small cross section in order that the total resistance of the furnace may be sufficiently high to permit the use of relatively small currents. The furnace as made has a resistance when cold of 0.14 ohm. This result is obtained by the special manner in which the graphite heater-tube is cut. Furthermore the cuts are made in such a manner that the extreme ends of the tube develop exactly as much heat as the middle portion, and this permits great uniformity in the heating over a long length of tubular space. Such a tube when cut, if not properly protected, would be fragile mechanically and means had to be devised to make the heater-unit as a whole mechanically robust. This result is attained in a very effectual manner by carefully worked out details in the construction.

Carbon or graphite, as is well known, is readily attacked by oxygen when above a red heat, and it was

FIG. 2.—REMOVING A UNIT

recognized that, if a unit were to last for many heatings, say forty or fifty, it must be effectually protected from oxidation. Perhaps the accomplishment of this result, without making use of a vacuum or by passing through the furnace any protecting gas, presented the greatest difficulty and expense. An electric furnace can only be thoroughly tested by destroying it, in which respect it is like a skyrocket. The result was finally attained by mounting the heater-unit in a molded refractory surrounded by what amounts to a hermetically sealed casing of monel metal. The CO atmosphere is developed by graphite, *which is not a part of the re-*

*"Some Effects of Temperature Upon the Resistance of Graphite and Carbon," METALLURGICAL AND CHEMICAL ENGINEERING, May, 1913.

sistor, and soon fills the furnace and effectually protects the graphite heater-unit for continued heating.

The terminals, which are always supposed to give trouble in furnaces which take a large current to operate, give no trouble and have a life longer than the unit itself. The furnace stands vertical and the two terminals project from the upper end of the tube at one side. They are covered with metal caps which can be quickly and easily removed.

The refractories in the furnace were selected, after much experimentation, to withstand a temperature of over 1800 deg. C. and to give at the same time the highest possible thermal insulation.

The tubular space in the furnace, which can be utilized for heating purposes, is 12 in. long by 1⅞ in. in diameter. The furnace casing is cylindrical in form and is made of monel metal, polished. It is 18¼ in. in length and 13 in. in diameter, on three legs 4½ in. high.

The furnace is so designed that in less than five minutes a graphite heater-unit can be withdrawn from the top of the case and a new one substituted. The metal terminal-caps, the refractories in the interior of the case and the top refractory piece, which forms the central portion of the top of the furnace, are all standard in size and easily and quickly interchangeable. In fact, perfect and easy interchangeability of all parts of the furnace is one of its special features.

FIG. 3.—HEATER-UNIT

This furnace will operate, of course, on either direct or alternating current and calls for a maximum of 170 amp. at 23 volts. It is preferable to operate the furnace with a transformer of 4 kw capacity and such a transformer is a part of the outfit. The regulation of temperature is accomplished by the kilowatt input and this is varied by means of a switch which throws into circuit a varying number of turns upon the primary of the transformer. All the heat, therefore, is developed in the furnace where it is wanted instead of in rheostats where it is not wanted.

The furnace cannot be burned out with the transformer which is supplied with it. The heater-unit after repeated heatings will in time begin to gradually grow higher in resistance and when this resistance has become so great that with the 23 volts furnished by the transformer the required high temperature cannot be obtained, the old unit must be replaced by a new one. The writer cannot state definitely the life of one of these units, because this depends so largely upon the maximum temperature at which the furnace is operated. He believes, however, that it is a conservative statement to say that a unit may be heated to a temperature of 1500 deg. C forty or fifty times, and perhaps oftener. All other parts of the furnace are practically indestructible. He has had great satisfaction in using this furnace in feeling absolutely assured that in the midst of an important measurement the furnace will not burn out or otherwise fail to operate. Also, that nothing that he may put in the furnace, in the way of metal vapors, etc., will in any way injure it.

By the manner in which this furnace is constructed the heat insulation is the most perfect possible and the high temperatures reached are attained rather by a slow accumulation of heat, which only in part escapes as it is being developed, than by a brief and rapid input of a large amount of energy. In fact, a furnace may be constructed with very little heat insulation and a very high temperature be attained quickly with large power input, or it may be constructed with a large amount of heat insulation and the same high temperature be attained by the input of a small amount of power continued over a long time. For some classes of work the former and for other classes of work the latter type of furnace best serves the purpose. This furnace is of the latter type and consequently the watt input required to bring it to a high temperature is very small considering the size of the heating space, but this small watt input must be continued for a considerable time before the high temperature is reached. The furnace heats very slowly and cools very slowly. Slow-cooling, for the work being done by the writer was desirable. The performance of the furnace in respect to rate of heating was measured several times and the accompanying curve gives a very good idea of how the furnace performs in respect to rate of heating.

The size of the furnace is that required by the writer in his work, but there is no reason why, with the same construction, the size may not be increased or decreased and the mounting be made horizontal as well as vertical.

The bottom of the tube when containing a crucible gives a perfect black body temperature and this makes the furnace admirably suited to the calibration of optical pyrometers.

Though this furnace was developed for his own researches it became apparent that it is so extremely useful for laboratory investigations that arrangements are being effected for its sale through the agency of the Arthur H. Thomas Company, of Philadelphia. The cost of development was large and no pains have been spared to perfect the furnace in workmanship and in minutest

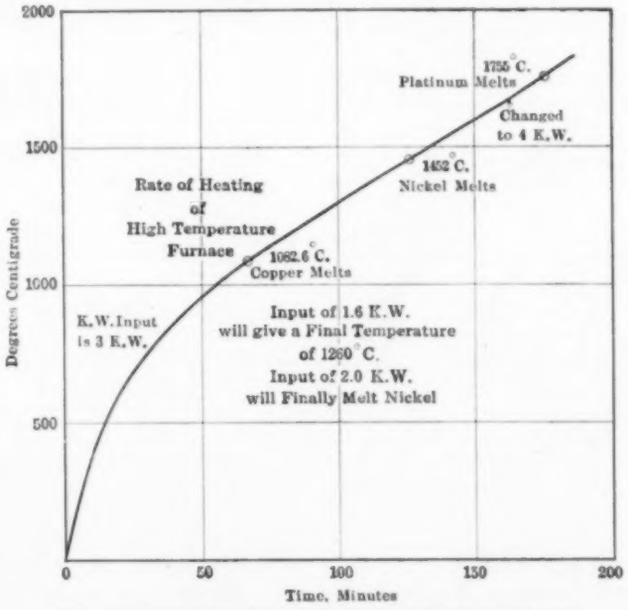


FIG. 4.—RESULTS OF TEST OF ELECTRIC FURNACE

detail, and to use the best materials obtainable for its construction. The polished monel metal case makes the furnace a handsome and cleanly piece of laboratory apparatus. The outside of this case never exceeds 200 deg. C. when the interior of the furnace is at the temperature of melting platinum. It will not be an inexpensive piece of apparatus, but it is hoped a very useful one for

those who have problems to solve in the temperature range 1000 deg. to 1700 deg. or possibly 1800 deg. C.

Palmer Physical Laboratory,
Princeton, N. J.

Notes on Chemistry and Metallurgy in Great Britain

(By Our London Correspondent)

The Institution of Electrical Engineers

Research Announcements

The Research Committee of the Institution has announced its intention of conducting extensive investigations into questions concerning the nature and properties of insulating oils and of magnet steels. With regard to switch and transformer oils the subjects of research are classified as chemical, physical and chemico-physical.

In the chemical sections the questions arising include the relations between temperature and formation of sludge with exposure to the atmosphere; the laboratory tests to determine the production of sludge under abnormal conditions; and the means of preventing the formation of sludge; the absorption of moisture at various temperatures and the laying down of a standard as to what constitutes a dry oil, and what effect on specific resistance and dielectric strength is produced by increase of moisture; the investigation of the comparability of results obtained by the usual tests for acid, alkali, sulphur, resin and other impurities, and the standardization of such tests; the composition of the gases liberated when an arc is formed in the oil; the nature of the effect produced by traces of nitric acid or ozone by silent discharge at the terminals of high voltage transformers.

In the physical section the investigations will include the effect of time on formation of sludge and the changes in viscosity, specific gravity, flash-point, dielectric strength, and specific resistance accompanying the formation of sludge; the effect of circulating air over the surface of oil on its electrical properties and the formation of sludge; the temperature rise to which oils can be subjected without notable change in their physical properties; whether any standard practice is extant for ascertaining the relative thermal transference in switch and transformer oils, and what standard forms of apparatus should be employed for the purpose.

The chemico-physical points include the effect of specific gravity, viscosity and variation of temperature on the formation of sludge; and whether the amount of carbon produced by an arc in any oil varies with the temperature of the oil, or whether at a constant temperature the amount of carbon varies with the specific gravity and viscosity and other properties of the oils.

Magnet Steels

In the research on magnet steels the following matters will be investigated: The relation in tungsten steels between percentage content of tungsten and coercive force when carbon content and temperature of quenching are constant; the effect in tungsten steel of manganese and silicon on the coercive force; the magnetic properties of vanadium and molybdenum steels (a) with varying content of V and Mo and the constant carbon, and (b) with constant V and Mo and varying carbon; the relation in high-carbon and in tungsten steels between the ductility or surface hardness and the residual magnetism; the best ratio of length to diameter for bar magnets of a standard tungsten steel; whether the transition temperature at which the steel regains its magnetism corresponds in high or medium-tungsten steels to Ar^2 or to Ar; the effect on the magnetic qualities of high-tungsten steels of brief preliminary heating to temperatures between 900° and 1,200°, which is known to lower the point of recalescence; a comparison of the values of the self-hardening steels of commerce and standard brands of tungsten steel in respect of remanence or of coercive force; the effect of procuring by prolonged heating in steam (as in the researches of Barus and Stronbal on carbon steel) on the remanence and coercive force of bar magnets of tungsten steel; the values of the coëfficients of self-demagnetization of horseshoe magnets and forms of magnets used in electricity meters; the values of the temperature coëfficients for matured magnets of nearly closed shape made of standard tungsten steel; whether and how the coercive force of matured bar magnets of standard tungsten steel depends on the intensity of the magnetizing field or on the time of magnetization; the magnetic properties of ferro-tungsten, ferro-vanadium and ferro-molybdenum when purified from carbon, silicon, manganese, sulphur and phosphorus; whether in a steel or pearlitic composition heated to 700° and very slowly cooled to 670° in a strong magnetic field any effect on the formation of the pearlitic structure will be produced; distortion as a result of quenching; and loss of magnetism as a result of vibration.

The arrangements for conducting both of these investigations are of a very complete character, and the co-operation of manufacturers and users has been secured to an extent which justifies the anticipation of practical results of more than academic value.

Producer Gas from Wood Waste

Mr. G. E. Lygo recently read a paper before the Junior Institution of Engineers on the generation of gas from wood waste by means of suction plants of the Whitfield type. He said that the increased cost of coal had induced power users having waste combustible materials at their disposal to consider the installation of wood waste plants in spite of its higher cost as compared with an anthracite plant.

Every kind of woody material could be used, sawdust, cotton seeds, cocoanut shells, fibre, bark, surface peat, up to blocks of wood six inches across. The area of the generator depends on the nature and size of the waste, but as a rule it was about two and a half times the space requisite for coal. For wood in large pieces a deep fuel-bed was necessary to prevent air passing through and causing ignition of gas in the upper part of the generator; while some dense fuels, like sawdust, worked best with a comparatively shallow bed. It was not necessary to use a vaporizer, because the keeping down of the temperature in the combustion zone was not essential.

The plant must provide for the cooling and washing of the gas immediately on leaving the generator, lest the heavy tar and dust should choke the connecting pipe. The Whitfield anti-fluctuator was an ingenious arrangement which ensured a steady flow of gas, and the variation of pressure in the suction stroke seldom exceeded one inch of water, but in a plant without the anti-fluctuator a variation of six inches was often met with.

The calorific value of air-dried wood was about 6,000 B.Th.U. per lb. The consumption per b.h.p. was dependent on the content of moisture, which varied from 10 to 20 per cent in air-dried wood, to 30 to 50 per cent in freshly cut timber. Material containing excessive moisture must be dried until there was not more than 60 per cent, because with a higher moisture content the generator fire would not burn evenly.

The value of the gas produced was higher

than that from anthracite, and was from 150 to 170 B.Th.U. per cubic foot as compared with 120 to 140 B.Th.U. for the coal gas.

Comparative costs of working were difficult to arrive at, much depending on whether the fuel could be used for other purposes, although generally it was almost valueless, but putting it at 10s. a ton it would equal anthracite at 25s a tone, and it then became a mere question of convenience. Where the wood waste was used to raise steam with a specially designed boiler the consumption per b.h.p. hour was from 6 lb to 10 lb., but with the producer the consumption was only 2½ to 3 lb. per b.h.p. hour. Experiments with an 84 b.h.p. engine driving a dynamo running at 105 volts gave 540 B.O.T. units for a consumption of 2,072 lb. of fuel, which equalled 3.83 lb. of fuel per kilowatt, with a Whitfield producer, for a ten hours' run.

In a certain factory the same amount of work was now being done with a producer plant, using wood waste alone, as had previously been done by a steam plant which consumed more than 500 tons of coal per annum in addition to the wood waste. His experience went to show that wood-working machinery in a factory made enough waste to produce all the power necessary to drive it when the waste was utilized in a producer, but with a steam plant such a result would rarely if ever be obtained.

The Alby United Carbide Factories

The report of this company for the year ended on the 30th of June last goes a long way toward justifying the optimistic views of the company's prospects expressed by the chairman at the last annual meeting. The profit on the year's working amounted to £80,448, which affords a dividend of 12½ per cent on the ordinary shares.

For the year 1911-12 the profit was £72,792, and the dividend was 6 per cent, and for 1910-11 the profit amounted to £36,473 and provided a dividend of 5½ per cent. Preference shareholders had the option of converting into ordinary up to July 1, 1913, and they have availed themselves of it to such an extent that the capital account now shows £108,392 of fully-paid preference shares and £441,608 of fully-paid ordinaries.

The company holds 500,000 £1 shares in the recently formed Nitrogen Products and Carbide Company, Ltd., the total capital of which is £2,000,000, and which has absorbed the Nitrogen Fertilizers, Ltd., and the Nitrate Products, Ltd.; and has the controlling interest in the North-Western Cyanamide Company, Ltd., of London, in which it is directly or indirectly interested to the extent of 94,000 shares. Of the 500,000 shares in Nitrogen Products, Ltd., 259,620 were acquired by purchase, and the last balance sheet shows an uncalled liability of £244,620 in respect of these.

Engineering Imports and Exports

The returns issued by the Board of Trade for the ten months ended on the 30th November show increases in both imports and exports of all the chief classes of engineering materials and products, although the figures for November exhibit a general decline in exports as compared with the corresponding periods of last year. For the ten months the imports of iron and steel, including manufactures, amounted to £12,558,389, and the exports to £45,634,880, the respective increases being £2,068,367 and £6,110,923. Imports of other metals, including manufactures, totaled £27,154,415, an increase of £1,595,432; and exports reached £11,128,323, an increase of £1,113,727. In machinery the imports are valued at £6,101,150, an increase of £455,327, and the exports are put at £30,760,860, an improvement of £3,258,605. New ships were imported to the value of £29,101, an increase of £2,449; whilst exports worth £10,142,785 show a rise of £4,468,843.

For the month of November alone imports of iron and steel increased £108,674, but exports decreased £302,098; imports of other metals fell £367,515, and exports also fell by £174,678; electrical goods showed a rise of £7,035 in imports, but a decline of £189,816 in exports; imports of machinery increased £6,545, and exports decreased £174,574; imports of new ships rose £726, whilst exports decreased by £237,924.

Market Prices

November, 1913

	£ s. d.
Aluminium Ingots, ton	96. 0. 0
Alum, lump, loose, ton	5.10. 0
Antimony, Star Regulus, ton	28.10. 0
Borax, Brit. refined crystal, cwt	18. 0
Copper sulphate, ton	24. 0. 0
Caustic soda (70/72%, white), ton	10. 5. 0
Copper ore, 10 to 25%, unit	12/1½ to 12. 7½
Ebonite rod, lb.	4. 6
Hydrochloric acid, cwt	5. 0
India rubber, Para, fine	3. 1
Mica, in orig. cases, medium	3/6 to 6. 0
Petroleum, Russian spot, gal	9¼
Quicksilver (Spanish), bottle	7.10. 0
Sal ammoniac, lump, firsts delivered U.K., cwt	2. 2. 0
Sulphate of ammonia, ton	13. 0. 0
Sulphur, recovered, ton	5.10. 0
Shellac, cwt	4.12. 0
Platinum, oz., nominal	9. 5. 0
Tin ore, 70%, ton	£112 to £115
Zinc, Vielle Montagne, f.o.b. Antwerp	25. 0. 0

Tin opened at £182 and was £183 on the 4th and 5th, thence fell to £179 (11th), and remained between that price and £181.10.0 during the month, being £179 on the 24th, and closing £178.7.6.

Copper opened £72.10.0 and declined steeply to £71.10.0, where it remained till the 5th, then again fell, reaching £67 by the 10th; rose to £68.10.0 on the 11th, and held fairly well till the 20th, when it again fell off, touching £65.5.0 on the 24th, which price brought buyers in raising it temporarily to £69 and closing at £66.18.0.

Hematite opened at 64/- and dropped to 62/6, then rose sharply to 67/- (4th) and fell away again to 63/- (5th to 10th). It continued to fall slowly, being 61/- on the 24th, and closes same price.

Cleveland opened at 51/- and fell away to 49/- in the neighborhood of which price it remained, dropping to 48/7½ on the 21st, and closing at 49/4½.

Scotch Pig opened at 57/- and remained steady at just under for four days, then dropping to 56/- (10th) and kept falling till it touched 54/9 on the 18th; recovered to 55/3 on the 19th, but had again relapsed to 54/9 by the 24th and closes at 55/4½.

Lead opened £20.5.0 and declined to £19,17.6 (14th) and £19.10 (17th to 20th), and £19.5.0 (21st). It closes at £18.10.0.

Differences

Lower	£ s. d.	*Higher*	£ s. d.
Copper ore unit	7½	Quicksilver, bottle	5. 0
Sulphate of ammonia	5. 0		
Shellac	2. 0		
Tin, ton	3.12. 6		
Copper	3.12. 0		
Haematite	3. 0		
Cleveland	1. 4½		
Scotch pig	1. 4½		
Lead	15. 0		

The Arizona Copper Co. produced only 1400 tons of copper during the month of November, 1913. Considerable progress has been made in getting the new furnaces into operation.

A new metallic alloy of iron, manganese, aluminium and nickel has recently been patented by Walter Rubel, of Berlin, Germany. The metals are melted together in proportions corresponding to the multiples of their atomic weights expressed in the formula 4(FeNi) + 8Al + Mn. The alloy is said to be useful as an addition to copper and aluminium to form a bronze.

Utilization of Wood Waste.

IV—BATH PROCESSES.

BY JOHN E. TEEPLE, PH.D.

Among the various methods of utilizing waste wood or obtaining valuable byproducts from wood, we have mentioned "Bath Processes." It might be difficult to differentiate encyclopediacally between a bath process and a solvent process, or to determine the particular

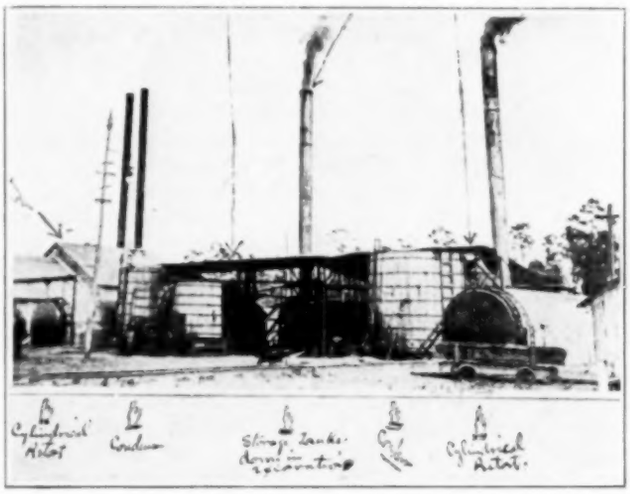


FIG. 1.—GENERAL VIEW OF BATH PROCESS PLANT

point where a bath ceases to be a bath and becomes a solvent. In practice, however, the two systems have been entirely distinct, have developed independently and worked on entirely different lines. Broadly speaking, the bath has always been non-volatile, and the solvent volatile. The bath has been employed on cord wood and the solvent on disintegrated wood.

The first developments of the bath process were in North Carolina about ten years ago. Two plants of very considerable size were built and later remodeled, but neither of them has operated for several years. The investment here considerably exceeded one hundred thousand dollars. Operations were presumably conducted under the Weed (1905) and the Mackenzie patents.

The next development was in South Carolina where an experimental plant was built to operate under the Davis (1904 and 1906) patents, but by 1907 it had ceased to develop. The next step was the construction of a plant in Georgia operating under the Pope patents. This plant at the present moment is in the hands of a receiver, with outsanding stocks and bonds said to amount to many hundred thousand dollars.

The final progress of the idea was to Florida, where the largest of all the bath process plants was built and started operation in 1911. This last plant also ceased operations during this present year, so that now none of the five attempts is a going concern. On the other hand, conditions and prices that have existed in naval stores this year are unusual, and it may well be that some one or more of these plants under more favorable circumstances might resume operations.

The fundamental idea in all these plants was the use of a liquid bath in actual contact with the wood to remove valuable constituents of the wood. The first bath used was melted rosin. Rosin of the common grades melts around 120 deg. C., and when in a liquid state can be handled readily by pumps through pipes. Details of the process differed of course in the several plants and in the same plant at different times. In one method the wood in four-foot lengths was loaded into cars made of latticed iron and each holding nearly a cord. Ten of these cars were then run into a cylindrical retort and the door closed. In some cases the sides of the retort interiorly were squared up with cement so that the rectangular cars used would occupy nearly all the available space inside the retort. In one case the retorts were concrete instead of steel.

The rosin bath kept liquid in large vats or storage tanks was then pumped through a system of coils used as a heater, and thence into the bottom of the retort at a temperature of, say, 190 deg. C. As pumping continued the bath came into actual contact with the wood, and heated it to a point where the mixed turpentine water and oils in the wood vaporized and left the wood. The bath overflowed into a vaporizing chamber where with the injection of steam, if necessary, the volatile parts were removed and then condensed. Thence the bath returned to the pumps and heaters to continue its circuit until the wood was sufficiently extracted, usually about eight hours. At the end of the extraction the bath was removed from the retort, leaving the wood freed from most of its volatile constituents, still in cordwood shape, still containing its rosin and suitable for fuel or for destructive distillation.

It was assumed in the early stages that the rosin bath would increase by extracting rosin from the wood, so that rosin could be marketed from time to time. Experience, however, usually showed the contrary, and it was more often necessary to replenish the bath with purchased rosin. It will be seen that the operation was continuous during any single distillation, and considerable quantities of rosin were in circulation in the retort, pipes, pump and heater.

A moment's consideration will suggest at once that in any accident causing stoppage of the circulation and cooling of the bath the rosin would "freeze," and there would be heavy bills to pay and no pitch hot. Such an accident occurred more than once in spite of precautions and duplication of machinery. A further disadvantage was the heavy wear on the heating pipes causing leaks. If these leaks occurred inside where they were hidden from view the rosin bath could leak away and serve as fuel for the heater for long periods before it was detected. If the leak occurred in the

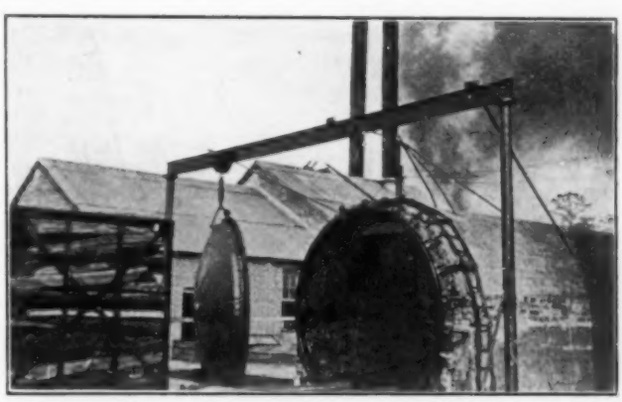


FIG. 2.—CYLINDRICAL RETORT AND CAR OF WOOD IN BATH PROCESS PLANT

open there was serious danger to the plant from fire.

As to yields, the claims as usual were liable to be high. The tendency seems to be the same as it is with an applicant for a patent; claim everything in sight, because you certainly will not get credit for anything you don't claim. The ordinary statement given is that 1000 pounds of wood gave 7½ gallons of oil, half of this being turpentine and the remainder oxidized and

hydrated derivatives grouped as pine oils, and rosin oils and other decomposition products of the rosin bath caused by the high temperature.

It seems worth while to insist again though, that this whole question of yields is a purely relative one, depending on the wood. You can't get 10 gallons of turpentine out of 8-gallon wood, and one dosen't deserve any particular credit for getting 12 gallons out of 18-gallon wood. The fact that you squeezed two pounds of water out of a sponge while I only squeezed one pound out of another sponge doesn't entitle you to crow over the superority of your squeezing process till we know a little more about the relative capacity and humidity of the two sponges.

I have seen a plant working by the steam process get an average of 7 to 9 gallons of turpentine from its wood day after day, and I have seen the same plant without other change than a little intelligence and forcefulness behind the men in the woods, produce 14 gallons of turpentine per cord day after day, with no material increase in the cost of the wood. Until we are ready to state yields in terms of percentage recovery of all the turpentine, oils and rosin in the wood we can draw very few conclusions from figures excepting as post mortem exhibits to show why the plant died.

In any case the bath processes made reasonable recoveries of turpentine and oils and had over half of their wood left after furnishing fuel to their rosin baths. The last two plants constructed erected destructive distillation plants of the car and oven type to char this wood and obtain tar, charcoal, various oils and some low-grade turpentine. This was a logical step, but apparently more was required to save them from financial difficulty. At any rate none are now in operation. To obviate the difficulties of using a rosin bath many mixed baths were tried, using tar, tar oils, creosote oils, pine oils, pitch, etc., in various proportions with considerable success. It seems reasonable to suppose that under favorable conditions and good management some of these plants may still be a factor in developing the industry.

50 *East Forty-first Street, New York City.*

International Electrical Congress

San Francisco, 1915

The International *Electrical* Congress is to be held at San Francisco, September 13 to 18, 1915, under the auspices of the American Institute of Electrical Engineers by authority of the International Electrotechnical Commission, and during the Panama-Pacific International Exposition. Dr. C. P. Steinmetz has accepted the Honorary Presidency of the Congress. The deliberations of the Congress will be divided among twelve sections which will deal exclusively with electricity and electrical practice. There will probably be about 250 papers.

Attention is drawn to the distinction between this Electrical Congress and the International *Engineering* Congress which will be held at San Francisco during the week immediately following the electrical congress. The engineering congress is supported by the Societies of Civil, Mechanical and Marine Engineers and by the Institutes of Mining and Electrical Engineers, as well as by prominent Pacific Coast engineers who are actively engaged in organizing it. This Congress will deal with engineering in a general sense, electrical engineering subjects being limited to one of the eleven sections which will include about twelve papers, treating more particularly applications of electricity in engineering work.

The American Electrochemical Society will hold a meeting in connection with the Electrochemical Section of the International Electrical Congress.

Notes on Open Up Ozonator Designs

BY A. VOSMAER, PH.D.

For the sake of convenience in handling the subject, ozonators may be classified under two essentially different headings, viz.: those which are based upon the principle of using some solid dielectric between the dischargers, and those which do not make use of any solid dielectric for this purpose. The first named have been the first in the field; they were for a short time threatened to be superseded by the second named class; the result, however, has been that they stand now in the front, stronger than ever.

Although the no-dielectric class has been forced to give way to the other, still it is of interest to discuss the former because it not only gives a better insight into the matter of ozonators in general, but will also cause a better appreciation of the dielectric system, if one knows why the latter has won the victory.

Bearing in mind that the object of discussing the non-dielectric system is to bring forth the advantage and value of the other class, it is logical first to deal with the former.

1. Ozonators Without Solid Dielectric Between Electrodes

From the year 1857, when Werner von Siemens made the first commercial ozonator, up to 1894 when Schneller took out his patent, the general thought prevailed that the use of a solid dielectric was essential to having the brush discharge with the exclusion of spark and arc.

Schneller was the first to prove that this is not the case, and it is interesting to note how a totally wrong reasoning led him to an arrangement that actually did work, though poorly.

Schneller assumed that the rôle of the dielectric was that of a high resistance in the path of the electricity and argued that as this was so we can as well place it somewhere else in the circuit and use some other material for it.

So he arranged his circuit in such a way that one of the terminals of the high—very high—tension transformer was connected to what he called a specific resistance, and from there to the sharp pointed discharger, discharging against a flat surface which was connected to the other terminal of the transformer and for the sake of convenience also to the earth.

We shall come back to this arrangement later on. Whatever we may think of the idea, it certainly proved that a solid dielectric between the dischargers was not an essential point in the art.

The second way of doing away with a dielectric (we shall henceforth thus abbreviate the expression of a solid dielectric between the electrodes) was to have recourse to high-frequency currents. This was Tesla's method.

The third method was Otto's, based upon the principle that an arc when drawn out will thereby be extinguished. Otto used revolving electrodes, that is to say, one revolving electrode inside of one fixed electrode.

When I saw Schneller's system at work and on the one hand was thereby convinced that the dielectric is not a *conditio sine qua non* for the maintenance of brush discharges, but also convinced, on the other hand, that Schneller's method was based upon a wrong assumption, I began to investigate the subject. After a good many years of experimental research and careful investigation I finally found that the whole secret of the matter lies in a true harmony between the different items that enter into consideration—voltage, polar distance, shape and size of each of the dischargers proper, kind of current supplied, etc.

If there be true harmony between all of these, then and only then is it possible to have brush discharge

and nothing but these going on and on any scale required.

So I got my first patent in the year 1897, but in actual practice it soon turned out that perfect harmony once established does not always stay on. For instance, some alteration in the speed of the dynamo will give rise to a change in voltage which may be large enough to endanger the state of equilibrium. That is the reason why I was very fortunate in finding an automatic device that absolutely controlled the system. I will discuss this later.

These four are the systems which work without a dielectric and are thus essentially differentiated from the dielectric system and also from each other. There are some interesting scientitfic details involved in these different systems which may be discussed, not on account of their commercial interest, since none of these systems has any commercial interest at all, but for the reason that they are of value for understanding the history and the development of the dielectric system.

(a) The Schneller System

Fig. 1 gives a diagrammatic sketch of Schneller's idea. Tr is the transformer, E the earth connection, O the ozonator and G the "specific resistance," as he calls them. This was a glass tube filled with about 80 per cent. glycerine the apparent ohmic resistance of which amounted to about 20 million ohms. In his large ozonizer (2 K W) there were 75 of these tubes connected in parallel to as many double discharging combs. The secondary tension was about 50,000 to 60,000 volts. All these figures refer to the original Tindal plant in Holland.

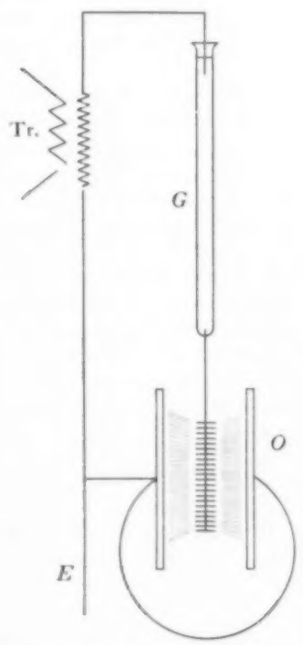


FIG. 1.—SCHNELLER SYSTEM

The actual working of that plant aroused in 1895 quite a stir. A great many scientists came to see this wonder, and full credit must be given to Tindal, who owned the Schneller patents, for having been the first to demonstrate on a fairly large scale the possibility of the sterilization of drinking water by ozone.

The first electrical question that at once comes up is this: Why did he use 75 tubes of 20 million ohms each in parallel instead of one of equivalent value? And the next question is this: Can that liquid resistance be supplanted by a solid one?

The inventor himself was never able to answer these questions and it has taken me considerable time to find out that said specific resistances did not work as such and could not be replaced by an ordinary metallic resistance, and that tubes filled with glycerine do not act through their considerable ohmic resistance but actually act as a pseudo-capacity of large value. If one inserts a condenser of large capacity in the system in series, then one obtains exactly the same result. The voltaic arc will not be checked *unless* the voltage be very carefully watched, so that it would never rise above a certain limit.

I remember when working with Tindal that to my great surprise they were very careful about the voltage. A man was watching it continuously. My surprise was due to the fact that the patentee claimed to be sure of brush discharges and to keep out other kinds of discharges.

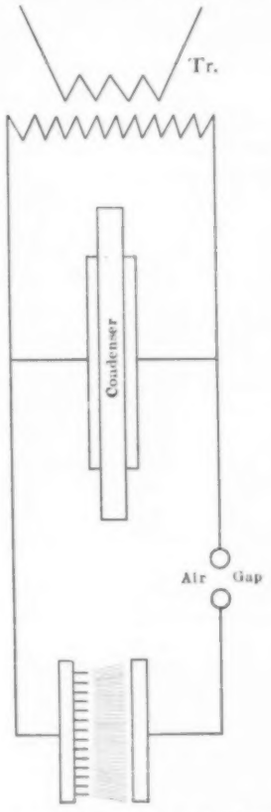


FIG. 2.—TESLA SYSTEM

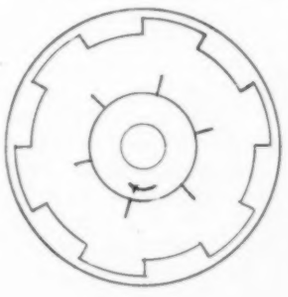
A posteriori it is all very clear, but at that time it was called a "wonder." The mistake of the Tindal people was that they did not work on a scientific basis. They did not know actually what they were doing, although the performance, being pioneer work, should be given full credit. It is so much easier to criticize afterwards than to invent before the realization of an idea.

In 1898 the same Tindal and Schneller patented an ozonator based upon the principle of the use of a dielectric, viz.: a layer of enamel, and had the shrewdness not to call this a dielectric but a means of obtaining a smooth surface.

It is a pity that the financial generosity of Tindal has not resulted in a better system. He was the man to whom we are all indebted for the knowledge of the wonderful effect of ozone on water. He gave the impetus for working out this scientific problem on a large commercial scale. Tindal died several years ago.

(b) The Tesla System

This system is too well known to need much comment. The special circuit comprising a condenser in shunt and a spark gap in series is familiar to all. The most strikingly beautiful brush discharges can thereby be obtained now without the least fear of arcing and have been enjoyed as a grand sight by many, but for the purpose of ozone making there is one objection to it. The yield of ozone per kw-hour is far too low in comparison to other systems, and this fact has prevented any actual use of it on large scale.



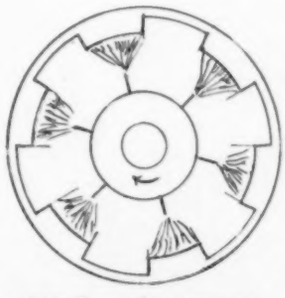


FIG. 3.—OTTO SYSTEM

The diagrammatical sketch, Fig. 2, shows the principle.

(c) The Otto System

If Otto, when he applied for his revolving-electrode patent, had known that it is better to prevent than to cure, and that prevention of arcs is quite possible when there is harmony between the revolving speed and the periodicity of the current, his system might have been an improvement. But as it is, not much benefit is to be derived from the arrangement.

Fig. 3 shows the principle in sketch. It is evident that there can only be here a question of cutting off arcs after they have been established, instead of making their appearance impossible. Had he claimed to turn the revolving electrode in synchronism with the alternating current, then the arc could have been avoided.

(d) The Vosmaer System

If, in order to obtain brush discharges and nothing but these, it is not necessary to have recourse to high-frequency current, or to the intercalation of a very high resistance, nor to have one or both electrodes in motion, what, then, is required to have things go as desired? This is the vital question. It is very easy to answer, however, because actual experiment on a large scale—up to 10 kw—has shown me that nothing else is required than to understand the subject thoroughly and on this basis to establish true harmony between the different electrical apparatuses.

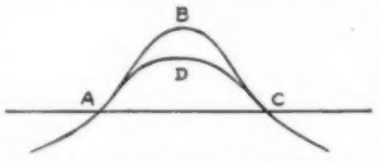


FIG. 4.—VOLTAGE WAVE CURVES

Remember that the spark is a disruptive oscillatory discharge, requiring a high density of electric charge at the place of discharge—hence the use of large spheres for this purpose.

Remember, too, that the voltaic arc has conditions of its own, that it represents the low-tension, high current-density discharge, started by actual transport of solid matter and continued by the conduction of gaseous matter at very high temperature, that the arc is started at small polar distance and can then be drawn out.

All these conditions are not fulfilled when one has a needle-pointed electrode, spaced at a distance of say half an inch from the other pole; when the potential difference is gradually increased there comes a moment when a brush is formed. If the voltage is kept at that value or a little higher it is possible to maintain the brush.[1] In my 2-kw. ozonator I could arrange it so that all this energy was taken up by brushes, no less than 240,000 needles being used in the apparatus.

The flow of electricity is such an even one, so smooth and regular, that no interruption need be feared, unless —and that is the point—there is a reason for it in the form of rise in voltage or particles of dust or metal playing the rôle of a solid conveyor from pole to pole.

The brush discharge from an alternating current supply is an intermittent one, in the first place because the points do not discharge unless they are positive; in the second place because the voltage is a wave and a certain minimum voltage is essential to discharge.

If the actual voltage wave be considered to be sinusoidal, the actual discharge voltage wave will be something like Fig. 4 shows, because the regular flow-off of electricity will prevent the tension to reach its maximum value.

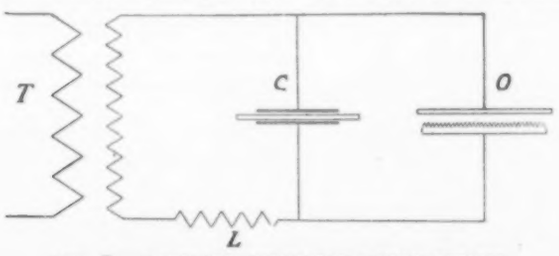


FIG. 5.—VOSMAER OZONATOR CONNECTIONS

Thus theoretically there is no difficulty in maintaining a regular brush discharge from properly shaped electrodes at proper distance, but in actual practical work it is hardly possible to realize the condition of absolute constant voltage and absolute dust-free air, and some means had to be provided for guarding against accidental circumstances.

That automatic safety arrangement was as follows: In the circuit from the transformer secondary ends to the ozonator electrodes there is a condenser in shunt, and a reactance coil in series (see Fig. 5). The object of this arrangement is that, through the combined effect of capacity and self-induction, one in shunt and the other in series, the original transformer tension is raised to a considerable extent, in fact multiplied by any number up to 15. Perhaps that is not the limit, though it was the limit in our experiments.

In actual work no such intense raise is wanted, my regular work having been done with a raise of not more than from 7700 to 10,000 volts. By this I want to say that the primary tension was 110 volts and the ratio of transformation being 70, that would give 7700 volts at the secondary terminals, but the special way of connecting up (patented by me and my partner, Dr. Lebret, in the year 1902) causes the tension to be 10,000 volts.

This raise of tension, however, also depends, as regards its magnitude, on the value of the resistance at 0. As soon as this drops, say on account of a spark caused by a particle of metal, then said raise in tension drops also, and by so doing ends the spark; in this way the spark is killed by its birth or even before that, because even the *tendency* to start sparking is *checked* by the special circuit.

Arcing is an absolute impossibility, as was repeatedly demonstrated when raising the primary voltage on purpose, say to some 20 per cent. The way of connecting up is altogether against the nature of voltaic arcs.[1]

It is useless to tell of all the technical difficulties that had to be surmounted before a 20-kw unit could be made. It worked beautifully. Occasional sparks were promptly extinguished. But my system for which I had been working so hard had to suffer the same fate as all the others. It had to give way to a better one, better taken in the sense of efficiency as regards output of ozone per kw-hour.

II. Ozonators With a Solid Dielectric Between Electrodes

(a) The Dielectric

The dielectric in an ozonator is subjected not only to the electric stress put on it, which, by the way, is a very severe one, but also to the heating effect of the discharge. We remind the reader that no more than 10 per cent. of the electrical energy is converted into ozone,[2] the rest is wasted as heat. Then there is the destructive effect of the ozone and the mechanical effect of the continual bombardment of charged molecules of gas.

There are not many materials that will stand all this. In fact there is but one at the present moment, viz., glass.

Nearly all the insulators made of or containing organic matter fail on account of the rapid destruction of it by the ozone generated, this being more especially the case with all those which contain rubber.

There are several lacquers that are not oxidized by ozone, for instance, shellac, and it might be that use could be made of this material. However, it is worth knowing that all laminated materials, such as micanite, shellaced paper, etc., cannot be used on account of their liability to peel off when subjected to the discharge and heat.

Celluloid cannot be used on account of the danger of taking fire. Vulcan fiber and fibrous material like it is

[1] See the Brush Discharge, by A. Vosmaer, MET. & CHEM. ENGINEERING, Nov., 1913.

[2] See Ozone, by A. Vosmaer, MET. & CHEM. ENGINEERING, Dec., 1913.

no good at all because the discharge will "eat" its way through.

Amongst the minerals there are but few that can be had in a convenient shape. But slate and mica have been in use. The first, however, is by far too irregular in insulating properties; the second is an excellent insulator, but its peculiar property of being a highly laminated structure excludes its use for the purpose in mind.

That leaves one more group, viz., glass, enamel, porcelain and quartz. Enamel is a kind of leadglass containing a considerable amount of metallic oxides. It is a very poor insulator, very sensitive to rise of temperature, very seldom a homogeneous mixture, and no good at all for the purpose. Strange to say, porcelain does not give satisfaction at all; when used in ozonators for a dielectric it very soon gives way; small perforations are set up within shortly, and that, of course, results in the voltaic arc which means ruin to the ozonator.

I believe this strange behavior of a material so highly appreciated in other branches of electrical engineering is due to the fact that after all porcelain is not a material of homogeneous composition. Quartz and its kindred substitutes, fails for the same reason. Its fusion has not been a complete one. The molecular cohesion is rather poor. It is very brittle. But it may be and we might even say it is possible that before long, properly fused quartz can be obtained in large masses and in convenient size and form.

Thus really nothing is left but glass. Now, glass is a collective name for a large class of material. There is such a variety in quality, properties and make that some classification has to be made.

The so-called lead glass does not possess the properties sought for. Of the sodium and potassium-lime glasses the latter is to be preferred; that is the kind known as hard glass, manufactured as a specialty in Bohemia. It is a flint glass of good composition.

Glass has the advantage over several other materials that it can be had in almost any conceivable shape, of any size and any weight, up to a certain limit, of course—which limit is never reached in ozonators, however.

A great many failures of ozonators are due to the unsuitable quality of the glass used as dielectric. Many laymen who also are ozonator inventors—and there are many of these—think glass is glass and they take the cheapest kind they can get.

But the manufacture of glass has become quite a scientific art and it is very probable that when the demand comes, glass manufacturers will be able to supply a kind of glass that just suits the purpose to a nicety.

As the situation is now, there is always some danger, because glass is a treacherous material. It may look well outside, but the inside may be largely overstrained, internal stresses being difficult to overcome. For the present the best policy seems to be to try all samples and keep the good ones.

The dielectric strength of glass varies between so wide limits and depends on so many circumstances that definite figures cannot be given. For one millimeter of thickness it may be between 10,000 and 70,000 volts. It largely depends on the shape and size of the electrodes used, on the kind of current, viz., direct or alternating current, on periodicity and very largely on the temperature, so that the variations are too large to give an average figure.

The effect of temperature on the dielectric strength is a very marked one. Glass is a regular electrolytic conductor at high temperatures, and that is one of the traps for ozonators. If through excessive strain the dielectric should become too hot it gives way through simple conduction, thereby establishing the arc discharge.

The conductivity of insulators is a very fascinating subject to discuss, but would lead us too far away from our subject.

Let it be sufficient for the present to state that the right kind of glass suits the purpose of its use in ozonators as a dielectric very well if all conditions are judiciously chosen and thought over and checked by experience.

(b) Principle of Arrangement

In Fig. 6 are sketched more or less different ways of placing the dielectric showing in (*a*) one glass dielectric and two air spaces, in (*b*) we see the omission of one of the two air spaces, in (*c*) we have one air space and two glass dielectrics, while (*d*) is merely a change in construction. Now these different ways can be combined to different shapes of electrodes, and that gives all the possibilities—not very many, indeed.

Details of construction may, however, bring about a great change in efficiency. For example, if ozone of great concentration be wanted, then there should be a great amount of electrical energy discharging in a small space. This, however, also means a great amount of heat, and it is absolutely necessary to carry away this heat through effective cooling of electrodes and dielectric, and this is a condition not so very easily fulfilled.

It is immaterial, as regards the principle, whether the glass be flat or curved. This means that it makes no difference whether the ozonator is built up of plates

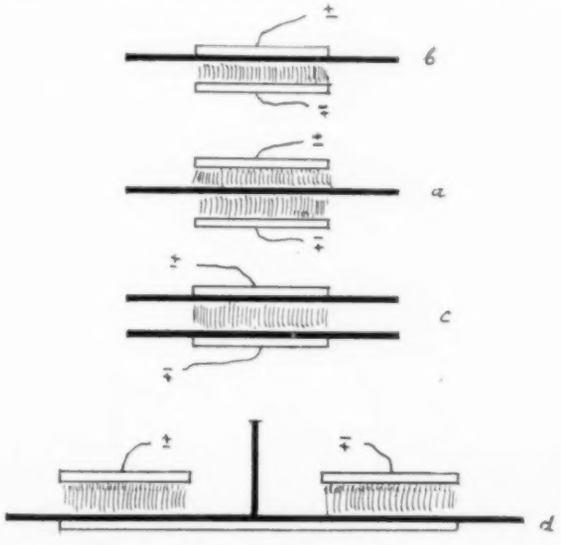


FIG. 6.—DIFFERENT ARRANGEMENTS OF DIELECTRIC

or of tubes. Some people have their reasons for preferring the plain plate, others again prefer the tube. Some are using all sorts of fancy shapes of electrodes, others believe in simplicity.

There is much less difficulty in constructing an ozonator for low concentration than there is for high concentration. For ventilating purposes, where a very low concentration is wanted, there is no need of artificial cooling, since the air passing through takes care of that.

Again, in small-size ozonators for individual use, the yield of ozone per kw-hour is of far less importance than the simplicity of the apparatus, so that, after all, though there is not much variety in the principle underlying different ozonators, there is quite enough variety in the several makes.

(c) Some Ozonators

THE SIEMENS OZONATOR

Werner Siemens was the first who constructed ozonators on a commercial basis, and after several improvements the Siemens tube still holds a prominent place. The first trial was made with an apparatus built up of two coaxial glass tubes, either coated respectively inside

and outside with tinfoil and partly filled with acidulated water.

Here we have a case of two dielectrics and one air space.

Later on use was made of mica tubes, which, of course, did not give satisfaction. Then the firm developed an apparatus built up of large plate glass dielectrics, but after in actual service it had been proved that the glass tube either makes a better apparatus or gives better results, the later Siemens ozonators are now substantially built glass apparatus, six of them joined in one casing. They consist of one electrode of metal, an air space, one glass cylinder as solid dielectric, then a liquid electrode, which serves the purpose of cooling at the same time, as shown in Fig. 7.

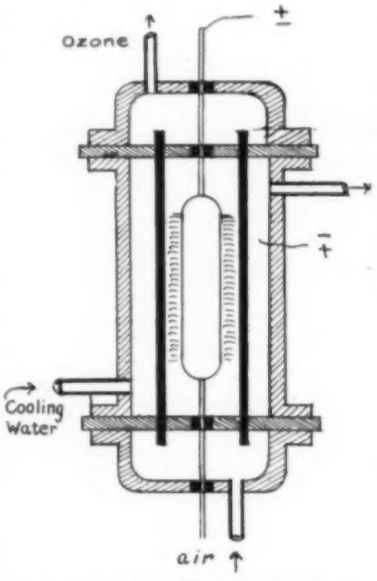


FIG. 7.—SIEMENS OZONATOR

We are all familiar with the general appearance of this type of ozonator, which has been published so many times on account of its being tested on a large scale and found to be efficient and reliable. The large European ozone plants are using this type of ozonator, which proves its fitness to do the work.

We may consider the Siemens tube to be the outcome of the original Berthelot laboratory apparatus.

THE GIRARD OZONATOR

The original Berthelot tube for laboratory use, modified so as to become an industrial ozonator, is what is the Gerard tube, the most prominent feature of which is the high output in ozone per kw.-hour.

The principle is that of Fig. 8, showing two dielectrics, one air space and two metallic electrodes, one of which is energetically cooled with oil. It seems that this arrangement is the best for producing high concentrations of ozone, although it is difficult to understand why it should be superior to the one-dielectric system.

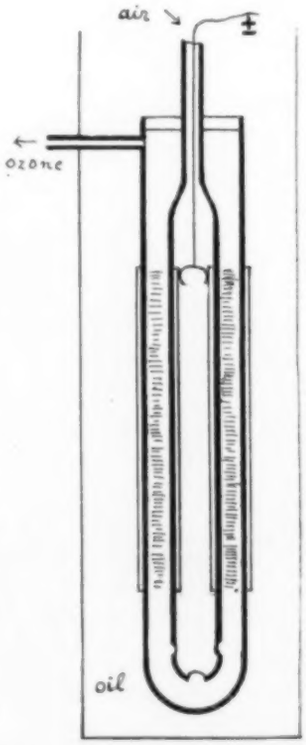


FIG. 8.—GERARD OZONATOR

THE OTTO OZONATOR

On finding that after all the rotating electrodes did not prevent the arc, Otto finally also took up the dielectric system, and kept his revolving electrodes, although the advantage of this moving part is not very obvious.

THE VOHR OZONATOR

Realizing the difficulty of obtaining a glass that will suit the purpose, and realizing that such is still more so in the case of tubes or cylinders, the Hudson Ozone Machine Company has arranged an ozonator in the style of a grid. It certainly has the advantage of cheapness as regards the dielectric, which in this case consists of nothing but strips of glass, easy to replace in case of damage and made of choice glass.

In the accompanying sketch, Fig. 9, its simplicity shows itself clearly. The electrodes discharge from both sides. As there is no artificial cooling the current density per surface of electrode has to be kept low so as not to cause a dangerous rise of temperature.

The grids are made in units and can be joined in a suitable casing. The system does not allow of obtaining extremely high concentrations, but as said repeatedly there hardly is a need for those very high concentrations. Personally I have done all the work with a concentration as low as one or a little over one gram per cubic meter, and that is quite enough, except in some very special cases. The secret of the use of low-concentration ozone lies in the knowledge of exactly the best way of application, and that is a matter of experience.

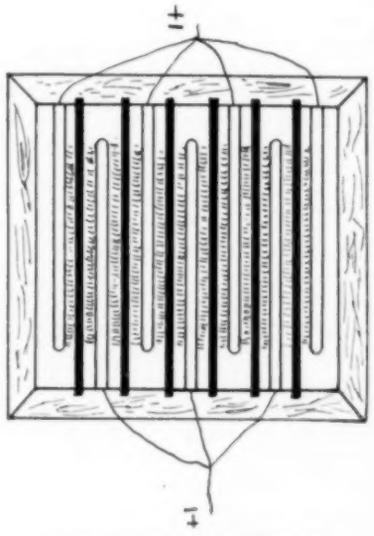


FIG. 9.—VOHR OZONATOR

There are several other ozonators on the market yet, and we could lengthen this article by enumerating and describing them from the patents, but that is not the object of this article. On the contrary, I have been endeavoring to condense it as much as consistent with good understanding. Moreover, as it is only in details that different makes differ, it would be of little interest to repeat again what has already been said so often.

I wish to conclude this by reminding the reader and prospective user of ozonators that at present they can be had for any concentration up to say 30 grams of ozone per cubic meter and for any quantity.

The Gerard and the Siemens apparatus seem particularly adapted for the manufacture of high-concentration ozone, the Vohr suits the purpose of lower concentration. Just what concentration is wanted for a given purpose cannot be said in a few words. The output per kw-hour is less for a high than it is for a low concentration so that it would be bad policy to first make a highly concentrated ozone and dilute it by mixing with more air. Most of the present applications of ozone can be successfully carried out with a concentration of about one gram per cubic meter of air; some require 3 to 5 grams, some no more than one milligram (see the article in the December number).

The vital point for an ozonator to do its work and to do it satisfactorily is that it shall not be run to its utmost capacity. It is better to stay a long way off that, because the more energy is used per unit of surface the higher the concentration and the higher the yield, *but* at the risk of a breakdown.

A common mistake of most people who start working on ozone is to push the discharge. At its best, this

method gives high figures for output but does great damage to the reliability of the apparatus. Experience must tell the operator the safe limit for continuous operation.

No more than 5% as a rule and never more than 10% of the energy is usefully employed in the conversion to ozone, the rest is wasted as heat and should be taken care of accordingly.

By way of comparison it may be said that the original Schneller system gave 4 grams of ozone per kw-hour, his latter system gave 7, the Vosmer system gave 12, the Siemens 30, the Gerard is said to give 50 to 80. These figures must not be looked upon as of much importance. They are liable to change according to circumstances and are not strictly comparable.

It is a mistake to look only for high output per kw-hour. There are many other items of as much or sometimes even of more importance, for instance, reliability, constancy, cost of installation, cost of maintenance, and many others.

From an electrical standpoint ozonators may be looked upon as condensers of enormous capacity, both pseudo and real, and as this is a rather unusual load for an alternator, the phase difference should be corrected by some self-induction so as to get the full power out of the alternator. This point is generally overlooked. We are used to look out for self-induction, but capacity is just as bad. It is less common and hence less thought of. We all know of the Ferranti effect caused by the capacity of long cables but here we have a case of extremely high capacity not met with in the ordinary daily practice.

Ozonators are always run in parallel and it is safe to group a number to be fed by one transformer so as to be free in making repairs or changes without interfering with the rest of the machines.

The fact that glass has to be used for ozonators and that it is liable to break, limits the size of a single apparatus to a convenient size. Hence their great number in large plants such as are now in very successful operation in Europe.

Those who never worked in the field of ozonators usually wonder why it is not practical to place a large number of them close together and have one casing for them. Well, the reason is that apart from the fact that one has to provide for a large cooling surface, there is another objection to doing so, that is their individual electric fields. These are obnoxious in a terrible way. These individual electric fields are rather hard to calculate and not so easy to shield off as one might expect from ordinary work.

It is all a question of experience to be able to arrange matters in a satisfactory way, here as in any other branch of applied science, but here especially, because rather unusual factors are here encountered. But the fact that in Europe many very large plants do operate satisfactorily indicates that experts have overcome all the difficulties, and it is to be expected that within the near future ozonators will be as common apparatus as electric furnaces.

341 *St. Johns Place,*
Brooklyn, N. Y.

The United States mineral production for 1912 as finally announced by the Geological Survey, was the greatest in the history of the country, exceeding even that of 1907, which has been considered the boom year. The total value of production was two and a quarter billion dollars.

Montana leads other states in the production of precious stones, this supremacy being due to the mining of sapphire. The value of these gems produced in 1912 was $200,585. The total value of metal production of Montana in 1912 was $70,000,000.

History of Electric Furnaces

BY WOOLSEY MCA. JOHNSON AND GEORGE N. SIEGER

The electric furnace can be described as a short circuit under control. It can also be defined as a metallurgical apparatus for the utilization of the thermal effects of the electric current for an industrial purpose. Electrical energy is turned into "commercial energy," or something is given "form-value" by the electric furnace. The thing that is the driving force of the industrial operation is the electric current and the thing by which the energy is usefully applied is the electric furnace.

Now so long as power was derived from some primary electric battery no practical effect was attained for the reason that it was too difficult to get power enough to do much work in the electric furnace, even though

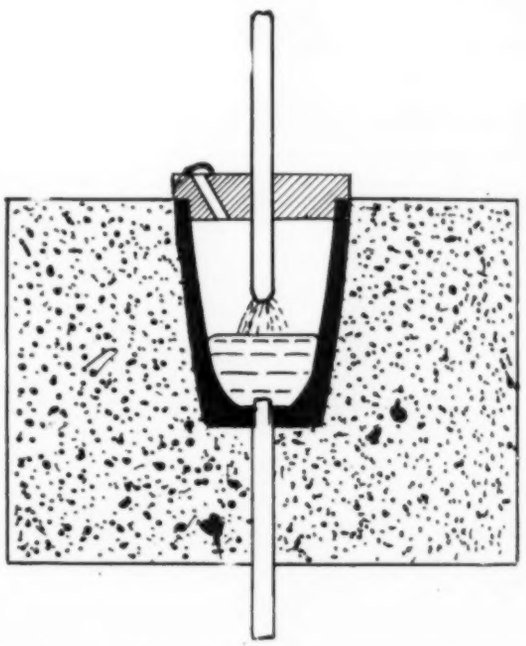


FIG. 1.—VERTICAL ARC TYPE OF ELECTRIC FURNACE

the cost was not at all considered. Later the dynamo was practicalized by Edison, Siemens and others. When this was done some adequate source of power was at hand and the experimenter having a generator upon which he could rely, could turn his attention to the electric furnace.

Accordingly, prior to 1876 we find but little accomplished in the electric furnace save of purely scientific interest. Sir Humphrey Davy—in 1800—was alive to the possibilities of electrically generated heat and built a small "arc" furnace. Henry, at Princeton College, New Jersey, had an electric furnace that was more than a scientific toy. Pepys in 1815 made a few scientific experiments.

Despretz, in 1849, made the original furnace of the "resistance" type. But this was the "scientific" age of electric furnaces, when it was used by the investigator simply as an aid to scientific experimental work.

In 1881 Edison first exhibited the dynamo or electric generator and electric motor. This machinery had the virtue that it worked and was reliable and durable. Such parts and accessories as fuses, switches, porcelain cleats, insulated wire, etc., were developed by the American inventor as essential details of the dynamo in a form identical with the present form though crude.

With the practicalization of the dynamo the inventor of the electric furnace had a source of power that could

be relied upon. And thus the practical stage of the electric furnace started. Sir W. Siemens, in 1878, exhibited to the Royal Society at London an electric furnace of the vertical "arc" type in which he melted several pounds of steel and boiled off several pounds of copper. See Fig. 1. This furnace is the prototype

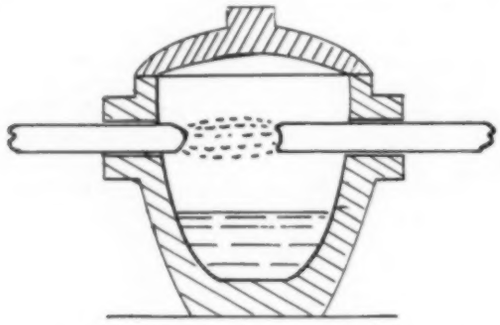


FIG. 2.—HORIZONTAL ARC FURNACE

of the Heroult steel refining furnace and indeed of any furnace that uses a vertical electrode.

Siemens also exhibited a horizontal "arc" furnace in which the heat is reflected down to the charge. This is the prototype of the reveberatory arc furnace such as is used by Stassano for refining or melting steel, by the late G. P. de Laval for smelting zinc ores and by Weeks for distilling crude zinc. See Fig. 2.

From the Siemens vertical type of furnace followed the Heroult-Hall electrolytic furnace for the production of aluminium. This was followed by the Wilson Carbide furnace. See Fig. 6. From these two came the slag resistance furnace or the buried arc type in such common use in the manufacture of the ferro-alloys. Siemens therefore can be regarded as the father of the "arc" type of furnace.

In 1883 E. H. and A. H. Cowles took up the question of smelting by electricity the zinc-copper ores of a mine near Santa Fé, New Mexico. Though the Cowles brothers were unsuccessful in this attempt they did develop the "resistance" type of furnace. See Fig. 4. In this a core of conducting carbon as coke in the charge itself carries the current in a horizontal direction. While no direct commercial result, at least no commercial result pronouncedly successful ensued, yet from this furnace was derived more or less indirectly the resistance furnace of Acheson for the making of graphite or carborundum. See Fig. 5.

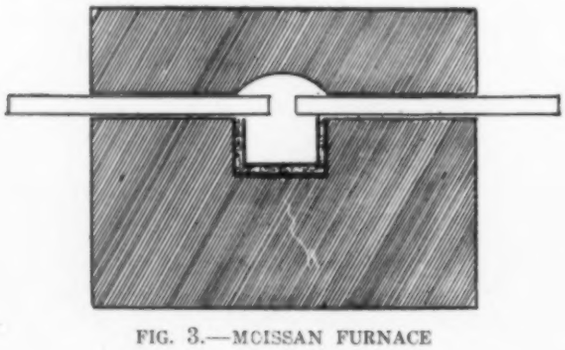


FIG. 3.—MOISSAN FURNACE

Along in 1890 the industrial limits of the electric furnace were clearly seen by certain far-sighted men, and it was recognized that the electric heat could only be used for such purposes as its specific innate advantages gave it a metallurgical monopoly.

This had been evident in the production of aluminium. Here by the combined power of electric heat and electrolytic effect, a metal that sold for $5.00 per pound had been reduced to 50 cents per pound. In calcium carbide, artificial graphite, and in carborundum there was found a useful product which could only be made in the electric furnace.

About the same time, water powers became harnessed and it was fashionable in financial circles to develop hydro-electric installations. This gave a large supply

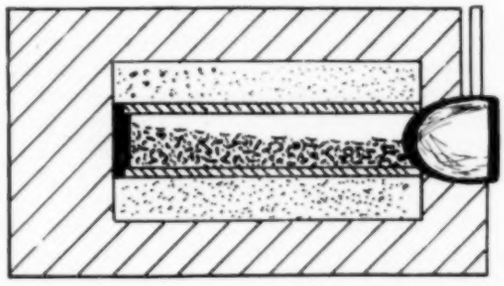


FIG. 4.—COWLES RESISTANCE FURNACE

of power for which there was not a great demand except at low rates when sold in large quantities.

About 1890 the real "commercial" age of the electric furnace started. The generator was developed to a practical stage, there was an abundance of cheap power and enough research work had been done to give the art the means of applying to industrial purposes the electric energy.

Along in 1890 Henri Moissan, a professor at Sorbonne, Paris, performed his spectacular researches on the electric furnaces. See Fig. 3. With upward of 200 hp at his disposal he concentrated this in less than a cubic foot of laboratory space. As electric furnaces nowadays rarely work at a power density greater than 20 kw per cubic foot, the results attained were remarkable. Almost any oxide was reduced, metals were boiled off in a short time, and the carbides of metals formed.

Unfortunately, such an operation, while it was brilliant from a scientific standpoint, especially the manufacture of diamonds, was not an unmixed blessing to electrometallurgy, for it gave rise to hopes and anticipations from which there was little realization.

When the calcium carbide business began to lag before acetylene found its present large uses, the companies making it turned their energies largely to the manufacture of ferro-alloys. As most of these are difficultly reducible, the electric furnace became the proper metallurgical means to employ. Along in 1905 the production of ferrosilicon high in silicon became an industrial success of importance. Ferro-vanadium, ferro-chrome, ferro-molybdenum and ferro-titanium followed. This expansion was due in part to the increas-

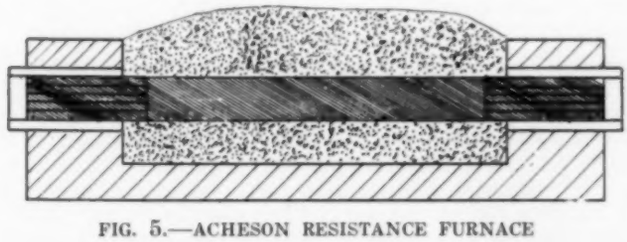


FIG. 5.—ACHESON RESISTANCE FURNACE

ing demands of the metal business for these alloys which were used as a basis for special steels or as scavengers in the manufacture of steel. This business has in certain cases been markedly successful in producing profits.

About 1905 the production of fine tool steel in the electric furnace came into engineering prominence. Steel when made in the crucible is expensive but its

duty is hard, for tool steel must be as nearly perfect as is practically possible to manufacture. The cost of production is large for the crucibles are expensive, the labor charge high, and the thermal efficiency miserably low. In either the Bessemer converter or the open-hearth furnace, it is hard to make steel dense without infinitesimal blow-holes or "sonims." The process of electric refining is more expensive but the quality of the product that can be made compensates for its higher cost. In the electric steel furnace there is a neutral atmosphere and the steel is "dead-killed." The reaction between the sub-oxide of iron and iron carbide is brought to a state of stable chemical equilibrium and the steel is never poured "gassy" while it is not an easy task to always pour steel dead quiet from a Bessemer converter or from an open-hearth furnace.

It seems an economic mistake for the electric furnace engineer to have tried to refine "tonnage" steel in

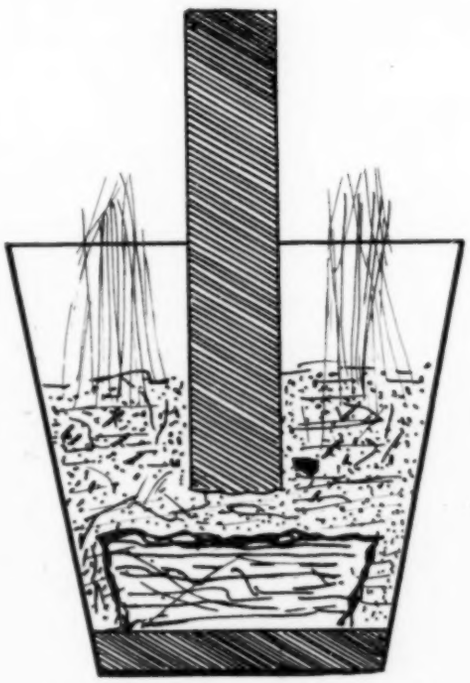


FIG. 6—WILSON CARBIDE FURNACE

the electric furnace when the crucible steel business lay open as a much easier point of attack in spite of the conservatism of the crucible steel makers. But the genius of Heroult had developed the combined process of partial refining by fire processes with subsequent electric furnace treatment. With the demand for heavy section rails by the railroads of great hardness and great toughness and with the proven industrial success of electric steel castings such as is done at Schenectady by the General Electric Co., however, the electric steel furnace on which Heroult has spent so much time, money and energy and to which art he has contrbuted so much, has two avenues of commercial expansion. There are few businesses that offer so great a profit with so little risk as does the manufacture of steel castings from cheap preheated scrap in the electric furnace.

The "induction" furnace has been subjected to commercial exploitation. It has had some success abroad but practically none in this country, for it is doubtful if of the 200,000 odd tons of steel made in the electric furnace in the United States one per cent has been made in the electric "induction" furnace.

The manufacture of carborundum came from the chance invention of E. G. Acheson. He noticed a hard substance in some electric furnace experiments. These were harder than glass and would slightly cut the diamond itself. From this came the carborundum furnace in which a mixture of sand and coal dust are turned into a useful abrasive. Mr. Acheson noticed, after his carborundum process had been commercialized, a layer of graphite in what had been the hottest zone of the furnace. This, he reasoned, had been formed by the decomposition of the silicon carbide. Accordingly, he developed the manufacture of artificial graphite by employing iron oxide or other substance to act as a high temperature catalyser to graphitize the carbon.

This process was successfully turned into the manufacture of graphite electrodes which have been in and of great service both in electrolytic and electric furnace work. It is hard to see how many electrolytic processes could be used at all without Acheson graphite anodes. Acheson graphite has the great advantage of standing sudden temperature changes without breaking. Often the increase of service more than pays for double increased cost as compared to carbon electrodes, although in most instances the value ratio to carbon is about 2.5 to 1.

With all these successful developments from 1890 to 1905 (the unsuccessful electric furnaces have perished and are forgotten) we might almost say that we have reached the end of the first "commercial" stage of the electric furnace. The electric furnace proved its usefulness in certain fields of its own. It did not begin to invade the field where the "carbon heated" furnace was clearly established until 1905.

Such developments as the manufacture of calcium nitrate in the electric furnace was along the lines of metallurgical monopolies.

In 1905 the advance of the old and tried processes began. The only two that had been successful before were the manufacture of carbon disulphide by Taylor and of phosphorus by the Oldbury Chemical Co. The electric steel furnace has proved its commercial worth in the manufacture of tool steel. The electric zinc ore smelting furnace and the electric brass furnace are destined to successfully invade the field now held by the zinc retort and the brass crucible.

The electric current is a powerful metallurgical instrument. But a keen sense of its own limitations must be present in the minds of the designer, inventor and promotor. The electric current resembles to the authors' ways of thinking—a hydraulic jack, but a hydraulic jack, while adapted for raising a steel furnace, is not made for raising a packing box.

Paving Brick from Blast-Furnace Slag.—At Middlesborough, England, several companies are engaged in the manufacture of brick from slag. The latter is taken from the furnaces in a car from which the molten slag is run into moulds carried on a wheel. The brick formed from the congealed slag is subjected to an annealing process before they are ready for use.

The Iron and Steel Institute announces the annual award of a research scholarship or scholarships, of such value as may appear expedient to the Council, founded by Mr. Andrew Carnegie, who has presented the Institute with $100,000 for the purpose. The award is to be made without respect to sex or nationality. Candidates must be under thirty-five years of age. The object of the scholarships is to conduct researches in the metallurgy of iron and steel. No restriction is placed on the locality in which research is to be carried on, provided it be properly equipped for the purpose. Appointments are for one, renewable at the discretion of the Council; the results of research are to be communicated to the Institute. Persons interested may secure further information by applying to G. C. Lloyd, secretary, 28 Victoria Street, London.

Handling the Raw Materials at the Iron Blast Furnace

BY J. E. JOHNSON, JR.

The average output of blast furnaces has increased in little more than a generation from about thirty tons per day to about five hundred tons per day. This great increase has occurred simultaneously with a decrease in the supply of labor relative to the demand, and a great increase in its cost.

These two circumstances have brought about great changes in the methods of handling the raw materials for pig iron manufacture. These materials are so generally ore, coke and limestone, that unless definitely stated, to the contrary, they will be meant when the term raw materials is used. In furnace parlance these are also known under the name of "stock," and the building in which the supply is stored to cover irregularities in daily receipts is known as the "stock house," a term which has survived the existence of any actual house.

The prime condition for successful operation of the furnace is that it must be run continuously. This is a fact that it will be necessary to emphasize many times in subsequent chapters. This term means literally twenty-four hours a day, seven days a week, fifty-two weeks a year, and for several years at a stretch. To enable furnaces to be operated in this way a supply of raw materials must always be on hand, in spite of the interruption to transportation of supplies, and other conditions which make regular daily receipts impossible. The first and obvious one of these conditions is the occurrence of Sunday, when transportation is always partly and generally wholly suspended. This makes it indispensable to have a supply of raw materials large enough as a minimum for two or three days' run, and rising as high as a six months' supply in many cases.

In the old days of small charcoal furnaces these were generally built close alongside of a very steep hill, and had a bridge running from the top of the furnace over to a leveled yard or space on the hill, served by a wagon road with an approach long enough to permit the hill to be surmounted. All raw materials were delivered by team into the stock house built on this level space, and unloaded, at first by shoveling from the wagons, later by wagons with loose bottoms, which could be pulled out, one board at a time. These materials were shoveled by hand into filling barrows, which were then wheeled onto a platform scale set for the correct weight of the given materials. The weight was adjusted by shoveling into or out of the barrows to make the balance correct, and the barrows were then wheeled across the bridge to the top of the furnace and there dumped. Of other equipment besides shovels, barrows and scales there was none. The number of men employed was not very great because the quantity of material handled in a day was small. Fifty years ago it probably did not average much over one hundred tons in twenty-four hours, and as a small number of men could handle this amount of material, equipment would not have been needed had it been available.

With the great increase in the size of the units, conditions became more and more difficult. The gangs of men required to feed a furnace grew to be large. The work was hard and it was very difficult to maintain full gangs. It must be borne in mind that no delays could be tolerated. A short suspension of filling would let the furnace get "down," which would probably be reflected in poor iron or in some other form of bad furnace work the next day.

More than 80 per cent. of the iron produced in the United States is made from ores mined in the Lake Superior region and transported wholly or partly by water to the points of consumption. Navigation on the Great Lakes is open nominally seven months, but actually only about six in each year. Therefore furnaces which derive their ore supply from this region are under the necessity of having on hand a six months' stock of ore at the close of navigation. If the furnaces are some distance removed from the receiving port of the ore, the latter may be stored on the docks or at storage yards maintained by the railroads. But the best practice increasingly tends toward shipping the ore directly to the furnace plant, and storing it in an ore yard devoted to that exclusive purpose, and not infrequently equipped with powerful and expensive machinery for putting the ore into the stock pile and reclaiming it as needed throughout the year.

A plant of four furnaces, of five hundred tons daily capacity, is not a large one as furnace plants go to-day, but such a plant consumes four thousand tons of ore per day, or 1,460,000 tons per year, and all of this must be stored during six months or less and half of it, say 750,000 tons, must be reclaimed from storage during

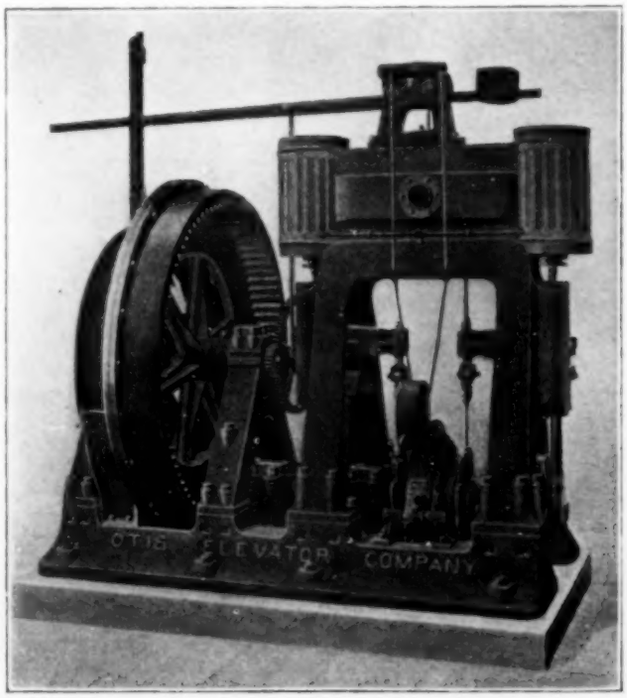


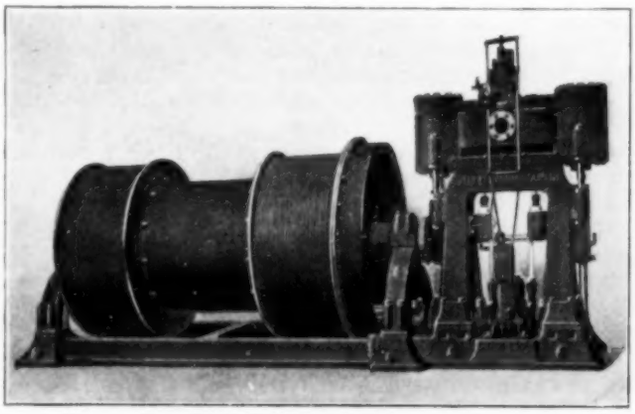
FIG. 1—STEAM-DRIVEN BLAST-FURNACE HOIST FOR FURNACE WITH VERTICAL HOIST TOWER

the six months which includes the winter weather, and principally in the severe climate which characterizes the central district of the United States. As it is characteristic of the Lake Superior ores to carry from a minimum of five or six, to a maximum of twenty-two or twenty-three per cent. of moisture, with an average of ten or twelve per cent.; and as this moisture is not combined with the ore, but only held by it in the shape of moisture, these great stock piles freeze to a depth of several feet, and the ore being soft and plastic, like clay or sandy loam in most instances, the frozen mass is exceedingly hard. Machinery well able to handle the material in its unfrozen condition would be unable to stand the service on frozen ore for the briefest period. This adds another very severe condition which must be met in handling the raw materials for iron manufacture in a preponderating portion of the business.

Power Hoisting

The first change from the primitive arrangement I have described was the introduction of power hoists for

taking the material to the top of the furnace. These were of two kinds, vertical and inclined, but irrespective of this in the majority of cases a platform was used onto which the barrows were rolled by men at the bottom. The platform was then hoisted, whether vertically or on an incline was a matter of detail, and men



FIR. 2—STEAM-DRIVEN HOIST FOR A SKIP-FILLED FURNACE

at the top, known as the top fillers, took the barrows off the car, distributed them around the top of the furnace and dumped them.

The introduction of power hoisting as a substitute for the bridge method of bringing the material to the top of the furnace was necessitated by the increase in the height of the furnace from some twenty-five or thirty feet to fifty, sixty and seventy feet. No hill could be found steep enough and high enough to lend itself to filling purposes for furnaces of such heights.

The operation of filling being continuous, and the need for capacity growing rapidly after the introduction of power hoisting, double acting hoists were introduced very early and are used almost universally, with certain exceptions to be noted later. By this means the platforms, cars and filling barrows balanced each other on the ascending and descending trips, leaving only the useful load of the charge to be hoisted. This effects the saving of a great deal of power, and permits the use of much smaller hoisting apparatus.

Many styles of hoisting apparatus were tried in the early days of power hoisting, hydraulic, pneumatic, water balance and various types of engine driven hoists were used. Nevertheless this was one of the earliest parts of the equipment to become standardized, and for many years there has been used a very simple type of vertical two-cylinder engine, with cranks at right angles, and the engine shaft geared to the rope drum with either a single or double reduction gear. These engines are not fitted with a link like that used for reversing locomotives and other high grade engines, but are reversed by running the steam in opposite directions through their ports. One set of openings constitutes the inlet when running in one direction and the exhaust in the other.

In order to operate successfully on this system the valves must be set without "lap" or "lead," the eccentrics being exactly at right angles to the cranks, so that the steam follows the piston full stroke, and is not used expansively, even to the slightest degree. As a result these engines are very extravagant of steam, using about one hundred and twenty pounds per horsepower per hour as against twelve to twenty pounds for ordinarily good engines in power stations.

In the last ten or fifteen years there has been a growing tendency to avoid this great waste of steam by the use of motor driven hoists, these obtaining their current from generators in the power station, driven by an engine using not much more than a tenth of the steam per horsepower that is required for the hoisting engine.

There are, however, problems of control which have had to be met and which have proven rather difficult. With the large masses of material now handled it is very important that the operation of hoisting be started and stopped gradually to eliminate the excessive stresses which would otherwise arise. These problems have been solved successfully with the steam hoisting engine by the use of supplementary throttles thrown in and out of operation by a cam traveling at a suitable reduced speed. In order to accomplish the same result with the electric hoist, sliding contacts and a great multiplicity of switches were at first considered necessary, so that the switchboard for such an apparatus was very large, elaborate and expensive.

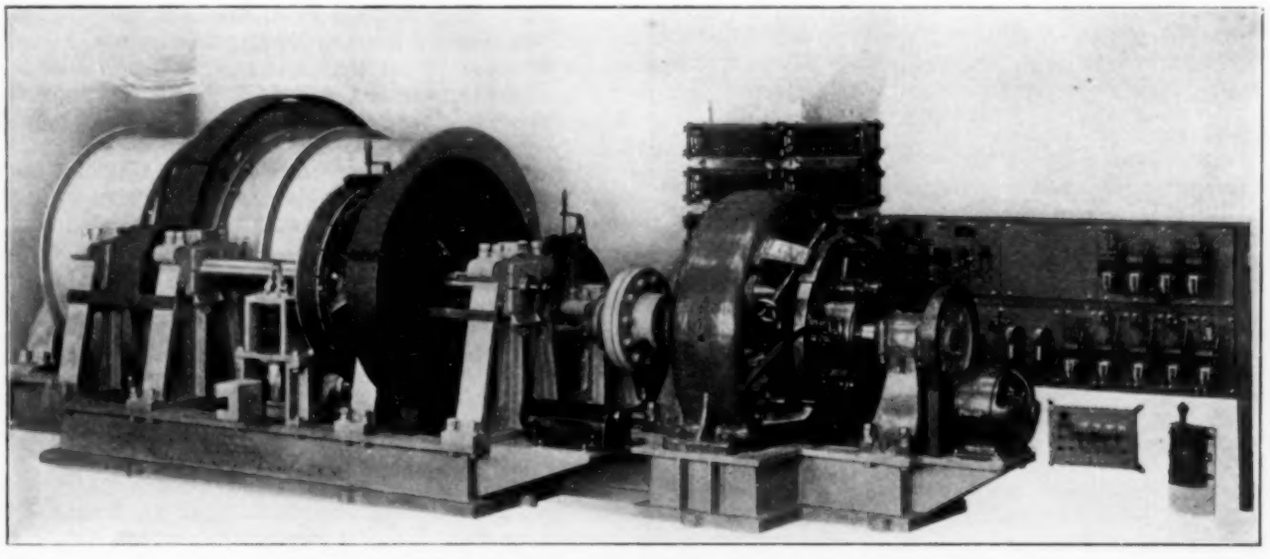


FIG. 3—ELECTRIC HOISTING APPARATUS

This problem has, however, been worked out successfully, and such electric hoists are now articles of regular manufacture, as are the steam hoisting engines previously mentioned. Fig. 1 shows a modern steam-driven blast furnace hoist for a furnace with a vertical hoist tower, where the ropes are led by guide sheaves from the tops of their respective cages to points vertically over the opposite sides of the drum, so that

when the rope from one cage is winding up that from the other is unwinding. The cages are thus balanced through the hoisting drum rather than directly. This hoist is built by the Otis Elevator Company.

Fig. 2 shows a steam-driven hoist for a skip filled furnace, in which there are two distinct drums, separated by a suitable distance horizontally so that the center of each drum shall be in the central plane of

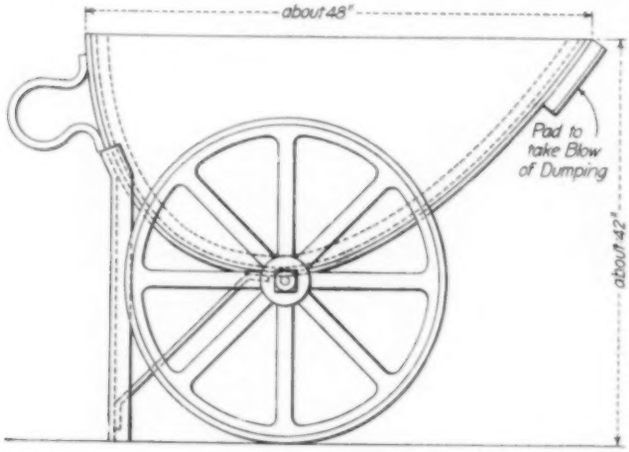


FIG. 4—ORE BARROW

its skipway. This will be more fully explained in dealing with skip hoists. This hoist is also built by the Otis Elevator Company.

Fig. 3 shows an electrical hoisting apparatus with its switchboard, built by the Lidgerwood Manufacturing Company. It will be seen that the rope drums in this are the same type as that shown in Fig. 2, this also being for a skip filled furnace.

Hand Filling and Filling Barrows

The system of handling raw materials in barrows was almost universal until the middle of the decade beginning in 1891. Many attempts had been made to eliminate at least a portion of the labor required for handling the great quantity of material needed as furnace outputs increased. But these were either mechanically unsatisfactory, or else their effect upon the work of the furnace was detrimental, in many cases disastrous. The reasons for this, in so far as they are known, will be given at some length in the chapter on operation; suffice it for our present purpose to say that probably ninety-five per cent. of all the iron made for thirty or forty years previous to the time mentioned was made from raw materials handled in filling barrows. These are so widely known that it seems almost unnecessary to describe them, but for logical completeness a brief description may not be amiss.

These barrows are universally two-wheeled, with at least one of the wheels loose on its axle to enable them to turn corners easily, and provided with stout legs on the rear end, which hold them level when standing. They are dumped by tipping forward on the axle, the wheels remaining stationary when they come against the dumping ring on the top of the furnace. On account of the vast difference in the specific gravity of coke, and ore, or limestone, a different type of barrow is generally used for handling these two kinds of materials. The ore and limestone barrows are as shown in Fig. 4, and the coke barrow as shown in Fig. 5. The latter are much larger and provided with a door in front, which is held shut by a latch, this latch being released from the rear a moment before the barrow is dumped. This construction is used in order to obtain a reasonable capacity for so light a material as coke. These barrows are built of steel plate, very substantially riveted together throughout, as they are subjected to continuous service and particularly to very heavy shocks when they are dumped, the nose of the barrow dropping forward on the iron dumping ring with a hard blow.

In ordinary practice the barrow weighs about eight hundred pounds, and will carry a load of about fifteen hundred pounds of ore. Ordinarily they are not loaded quite as heavily as this, as they then become too difficult for one man to handle, even on good floors.

The capacity of the coke barrow is roughly one-half as much by weight, so that the same number of barrows of coke as of ore are required per charge, the ore charge weighing normally about twice as much as the coke charge.

The physical labor involved in wheeling the barrows from the stock piles to the foot of the hoist is in ordinary practice roughly the same as filling them by hand. Therefore to dispense with hand shoveling, and continue the use of filling barrows, is only a half solution of the problem of eliminating manual labor in filling. Moreover, when the barrow system of filling is used it is necessary to have always one, and frequently two or even more men on top of the furnace to take the barrows from the cages to the furnace top, dump them and return them.

This labor is more expensive, man for man, than the labor at the bottom of the furnace, because it does not pay to have a foreman supervise the relatively small number of men required, and yet the operation of dumping, with which they are entrusted, is of the utmost importance, and slight variations in the method of dumping with hand filling, more frequently than any other cause, derange the work of the furnace.

For this reason it is necessary to secure a higher grade of labor for at least one of these top fillers by paying higher wages. Another reason for paying higher wages is that the men are under a certain liability to be overcome by the furnace gas when remaining for a long time on top. It is impossible to make the bell absolutely tight and keep it so all the while. Small particles of stock lodge on its seat and hold it open by an almost microscopic amount until the next dumping,

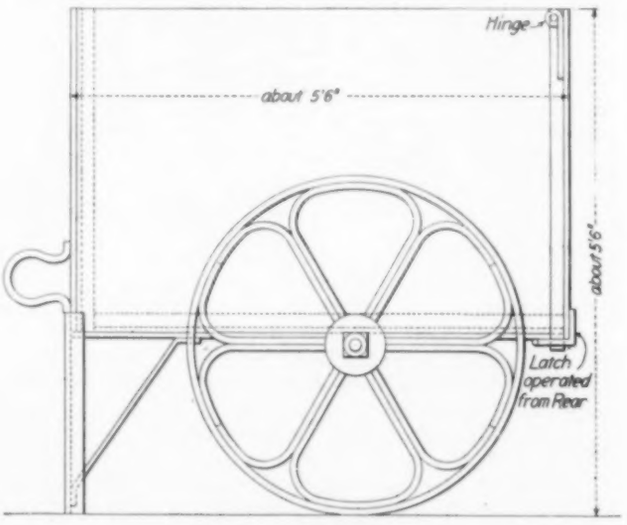


FIG. 5—COKE BARROW

when they are swept off, but very likely replaced by similar particles in some other location, so that the bell seldom shuts absolutely tight.

There are other points at which gas can escape, such as the test rod hole and various other places through which the gas will find its way in quantities frequently too small to be visible, but nevertheless tainting the

atmosphere sufficiently to overcome men exposed for a long time to this poison, even in this dilute state.

This possibility of accident, though real, is small, and fatalities due to the ordinary course of filling almost unknown, nevertheless it is sufficient to necessitate a higher scale of wages.

For all these reasons the elimination of manual handling of the stock from the bins to the furnace top was the goal of furnace builders for many years. But as the manager of the furnace was rarely the engineer who built it, he looked at the matter from a different point of view, and the many failures recorded to the credit of mechanical filling made managers very chary of risking their success and reputation in operating such plants.

The Duquesne Revolution

In the middle of the decade beginning 1891, furnace outputs had become as high as 400 tons per day in regular operation. The crews necessary to fill them by hand labor using these barrows were tremendous. Then, too, the capacity of the platform hoists had almost reached their limit, and it became almost a matter of physical impossibility to fill furnaces for any greater output by this means. Accordingly when about 1895 the Carnegie Steel Company decided to build at Duquesne a plant of four furnaces with a capacity of six hundred tons per day each, these furnaces being about twenty-one feet in diameter by one hundred feet high, they determined to strike out on new lines and eliminate altogether hand labor for filling.

M. A. Nieland was then chief engineer of the Duquesne works, and he designed what has since become one of the standard methods of mechanical filling, commonly known as the bucket system. This was a success mechanically and metallurgically and was the beginning of a revolution in the construction and operation of blast furnaces. It having been demonstrated that mechanical methods could be made to operate successfully on so large a scale, and with an enormous saving of labor, other methods to achieve these ends were soon devised, and as a result it is probably safe to say that three-fourths of all the iron now produced is made at furnaces mechanically charged.

The plan of eliminating labor wherever possible was carried out in all directions at this plant, whose mechanical equipment throughout was the best obtainable at that time. Thus the construction of this plant marks a distinct epoch in the history of the blast furnace in the United States.

The Delivery of the Stock to the Furnace

Returning now to the matter of handling raw materials from the stock piles to the barrows, this, as has already been stated, was at first done exclusively with shovels, but when the introduction of railroad transportation replaced the delivery of the raw materials to the plant by team, it was soon found necessary to elevate the tracks on trestles to facilitate unloading the material from the cars.

The cars were at first of the flat-bottom type, but very soon hopper-bottom cars, the prototypes of those in use to-day, were introduced. For these trestles became absolutely necessary. It was then a short step to install bins underneath these trestles, into which the materials could be dumped directly from the cars, and from which, in turn, they could be drawn directly into filling barrows without hand shoveling.

This eliminated probably fifty per cent. of the labor of filling, and, considering the great returns which the investment in bins pays in the form of labor saved, it is surprising that their introduction was not more rapid, but at the time of the Duquesne revolution many plants which considered themselves modern and well equipped were still handling their raw materials largely or wholly by hand. Since that time, however, the use of bins in large plants has become practically universal.

It will be seen that the order in which we have followed these developments, in the hoisting of the material, in its transportation from the stock house to the furnace, and in its delivery into the means of conveyance in the stock house, is the reverse of their logical order. But this is the way the development actually occurred chronologically, and to consider them in this order is perhaps justified on this account.

In discussing the development of mechanical filling, it is now necessary to revert to the subject of the delivery of the ore, for so large a part of the ore in this country is transported by water, and only during a relatively brief season, that this has had profound influence, not only on the handling of the ore at the ports of receipt, but also at the blast furnaces, because the machinery which was developed for unloading the boats was found almost equally valuable, with slight modifications, at the blast furnace also.

The conditions of water transportation imposed two difficulties on this traffic. First, the difficulty of unloading ore from the holds of vessels well below the water line, lifting it to a sufficient elevation and transporting it to a sufficient distance to enable it to be deposited in a stock pile, and, second, the necessity of doing this in the least possible time.

As has so often happened in industrial history, the solution of these difficulties resulted in an eventual

FIG. 6—BROWN HOIST FAST PLANT

benefit of enormous importance to the industry concerned. Less than a generation ago, boats of two or three thousand tons, the largest then in service on the Great Lakes, could be unloaded only by shoveling the ore by hand into tubs, hoisting these with ropes, dumping them on the wharf and then wheeling the ore up an incline onto the stock pile. This took vast quantities of labor, and as the men required physical stamina and endurance to stand up under this work there was a limited market from which this labor could be drawn. As a consequence the supply was always below the demand. This resulted, as it always does in such cases, in making the men arrogant, unreasonable and difficult to manage to a very high degree. This, in conjunction with the high wages it was necessary to pay them, made the unloading process very tedious and expensive.

During the decade beginning 1881, Alexander E. Brown began to apply his brilliant engineering ability to the problem of performing this work mechanically. His efforts met with the highest success, and other engineers, following in the path which he had blazed, developed still further the possibilities of mechanism in such work. So that while in 1885 it took about three

days to unload a vessel of three thousand tons, and cost about twenty-five cents per ton, it is now possible to unload vessels with machinery designed for this purpose in a shorter time than their cargo can be spouted into them from bins on the docks at the Upper Lake ports, and at a total cost for labor, power, maintenance, interest and amortization on investment of not over four cents per ton.

In the summer of 1912 a steamer containing something over thirteen thousand tons docked at 1:15 and was unloaded and had cleared for the Upper Lakes at 4:35 on the same afternoon. Three hours and twenty minutes to remove thirteen thousand tons of material. Probably not over twenty-five men were employed on the task all told, so that the labor cost was almost negligible. This was a record at that time, though it may have been beaten since.

Ore Handling Machinery

On account of the vast influence of the machinery developed for unloading vessels on the problem of stocking and reclaiming ore at the blast furnace, it will not be amiss to illustrate here some of the equipment by which these results are achieved. Fig. 6 shows a fast plant, designed and built by the Brown Hoisting Machinery Co., and may be considered the legitimate development of the first mechanical equipment built for this purpose by the same company twenty-odd years ago.

Where greater stocking capacity is required than the fast plant trolley travel will cover, traveling bridges are used, as shown in Fig. 7. In these the trolley travels on a straight member of the bridge, which is carried on the two traveling trestles shown. One of these runs on a double set of rails near the dock front, spanning one or more standard gauge tracks, the other on a single

FIG. 7—BROWN HOIST TRAVELING BRIDGE

FIG. 8—BROWN HOIST BRIDGE WITH FAST PLANTS IN BACKGROUND ON THE RIGHT

rail at the rear end. The bridge is pivoted to the trestles or legs so that it can be slewed at a considerable angle. The runway is carried beyond the line of the traveling legs on cantilevers, the outer one of which is hinged so that it can be raised up out of the way to permit the bridge to pass the spars of vessels. Equipment of this type is used particularly where the furnace plant is at the lake front. Where the stocking capacity required is so great as to necessitate the employment of bridges and where rapid unloading capacity for the vessels is also required a combination is made of the two styles of equipment. Several fast plants remove the ore from the vessels and dump it within reach of the bridge, which picks it up again and stocks it as required, as shown in Fig. 8. This system will be described more in detail in conjunction with the Hoover & Mason and the Wellman-Seaver-Morgan apparatus.

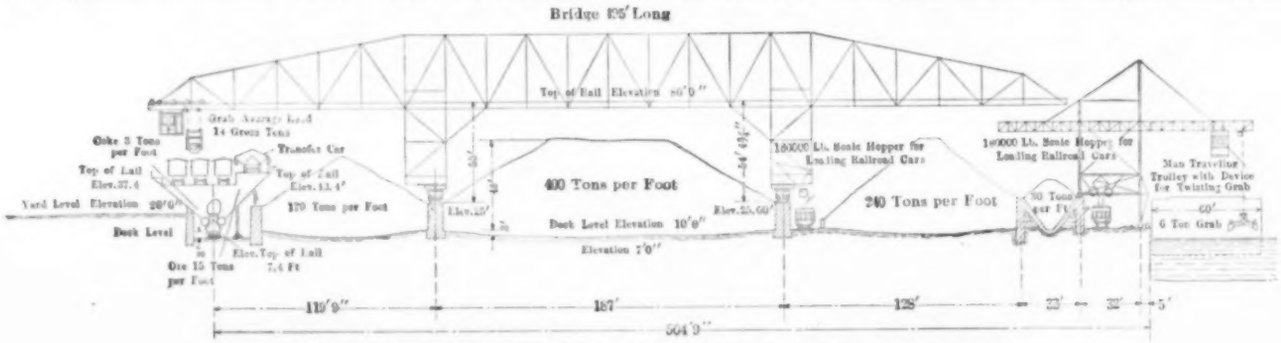


FIG. 9—HOOVER AND MASON UNLOADING AND STOCKING APPARATUS

Fig. 9 shows in diagrammatic style a Hoover & Mason unloading and stocking apparatus. This consists of two distinct parts. First, a gantry crane with cantilever extensions, one side of it is carried on wheels running on the top of the left hand wall of the ore trough, the other on wheels running outside the railroad tracks close to the dock face. This gantry supports a horizontal runway for a trolley from which hangs a grab bucket, shown in its open position after descending into the ship's hold, at the extreme left.

The method of suspension of this grab bucket is such that it may be rotated at any angle, for the reason that it can only go through the hatches when turned with its long axis parallel with the hatch. But in order to reach out beyond the hatch line and get the ore between the hatches, it is necessary for it to be able to rotate so that its long axis is at right angles to the line of the hatch.

The operation of unloading is carried on as follows: The grab bucket is lowered into the ore, closed, turned parallel with the hatch and elevated to a position alongside the cab hanging from the trolley. The whole trolley is then traversed back to one of two positions and there dumped. The first position is just to the left of the center of the gantry; the other on the left-hand extension of the cantilever outside the gantry. In the first position it discharges into a small hopper and from there the ore is loaded into railroad cars for direct shipment. In the second case it discharges into a concrete trough, from which the ore is reloaded by the second portion of the apparatus.

This consists of a traveling bridge one hundred and seven feet from center to center of supporting legs, with cantilever extensions on each end, running its total length up to four hundred and ninety-five feet. This bridge is also equipped with a trolley and grab bucket, the latter being of more than twice the capacity of the one which goes into the ship's hold, which is of six tons' capacity, the one on the main bridge being of fourteen tons.

This bridge travels on tracks laid on concrete walls, raised up well above the level of the ore yard, so that the ore will not run down on the tracks even when the yard is filled about to its capacity. The trolley and grab bucket on the main bridge use the ore in the trough as a source of supply, and taking it out of this trough carry it back to any one of the three piles under the three portions of the bridge and there dump it.

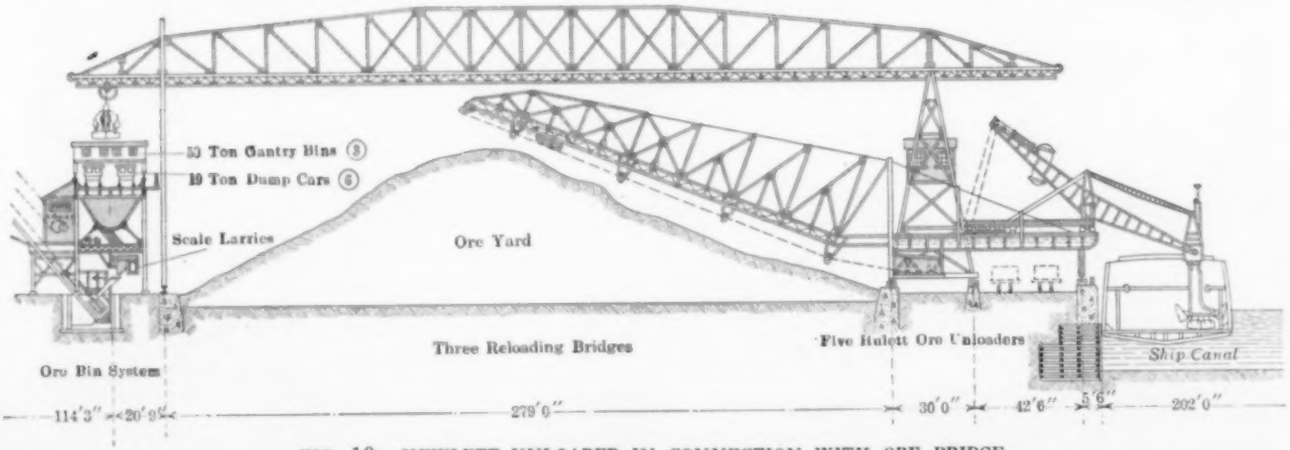


FIG. 10—HEWLETT UNLOADER IN CONNECTION WITH ORE BRIDGE

The drawing is so plain as not to need very much detailed explanation. Means are provided whereby ore may be shipped out by rail from two or three points. At the lefthand end of the drawing is the bin system for the furnace itself, this plan having been prepared for a furnace plant located just back of the dock line on the lake front, but a plant of the same general type would be used if the ore were merely stored in

the yard and shipped out as required through the winter.

It will be seen that the gantry unloaders are relatively inexpensive as compared to the main ore bridge, and it is therefore commonly possible to have five or six of these all working on a vessel at the same time, and delivering their ore into the concrete trough. The large bridge follows these and keeps the trough sufficiently clean for them so that they are free to dump in it when they move, as required by the contents of the hatchways, etc., thus the unloaders can be devoted to the purpose of unloading without much consideration of the question of ultimate disposal.

The bridge, on the other hand, is an extremely expensive apparatus, and, being many times heavier than the gantries, cannot be moved back and forth as they are, though it can move with sufficient ease to follow them at intervals and keep the ore trough free for them. By into the vertical position, it can be extended several feet horizontally, and by being lowered into the ore in this position serves to pull the ore toward the center of the bucket with a motion exactly like that of a gigantic hoe.

The operator rides in a small chamber in the stiff leg which carries the grab bucket. This is raised and lowered by a walking beam supported on trunnions, which are carried on a truck provided with means for traversing itself back and forth in the plane of the walking beam, that is in a plane at right angles to the dock line. The track on which the truck or trolley moves is carried by a traveling gantry bridge running on a pair of tracks, one close to the face of the dock, the other some distance inshore, as shown. The column, or stiff leg, which carries the grab bucket, is held in a vertical position irrespective of the angle of the walking beam by a parallel motion.

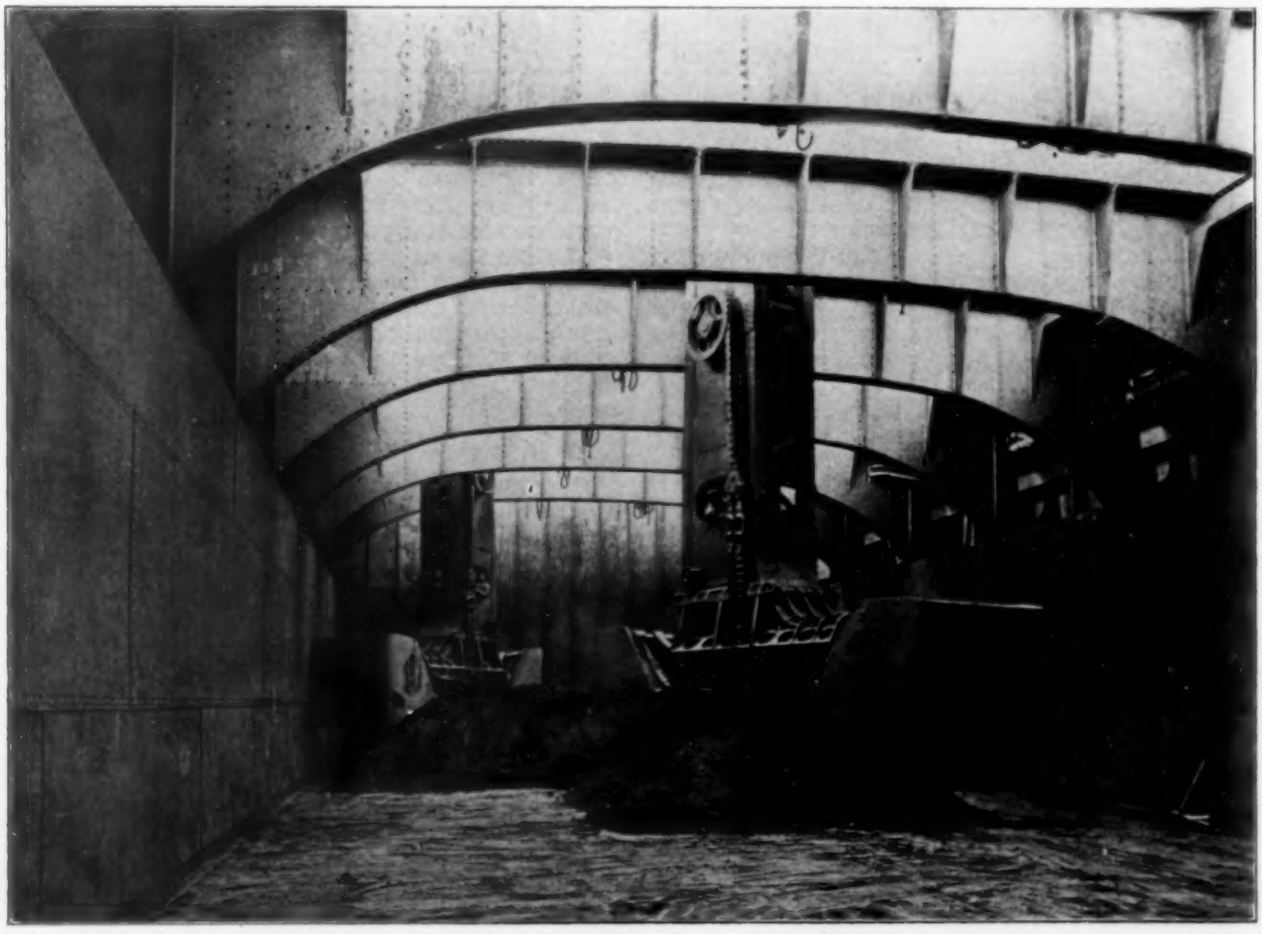


FIG. 11—HOLD OF VESSEL WITH THE GRABS OF TWO HEWLETT UNLOADERS AT WORK CLEANING UP THE FLOOR

this combination rapidity of unloading is secured without excessive expense for long-span bridges.

The latest developed apparatus for unloading is that brought out by the Wellman-Seaver-Morgan Company, and named for its inventor, Mr. George H. Hewlett, the Hewlett unloader. A diagram showing this in conjunction with an ore bridge is shown in Fig. 10. This apparatus is equipped with a grab bucket, a modification of the old clam shell bucket, but with two important differences from the machines of Brown and Hoover & Mason. First, the bucket, instead of being suspended by ropes, is carried at the lower end of a rigid column.

Second, the grab bucket, instead of having both jaws symmetrical, as is the case with the suspended buckets, has one jaw provided with a horizontal traversing motion, so that after it is opened, with the jaw swung up

The grab bucket and part of its load are counterweighted at the opposite end of the walking beam to reduce as much as possible the amount of power required for raising it and to facilitate its control.

In operation the walking beam is tipped to lower the grab bucket through the hatch, the stiff leg is then rotated to throw the longer arm of the grab bucket into any desired position, and if only a small quantity of ore remains in the hold at this location, the long arm of the grab is then used to pull several piles of ore together so as to make an approximately complete load for the grab, which it then picks up, so that it always goes up from the hatch loaded to its capacity. This capacity is very large. For a time ten tons was considered to be the limit, but several machines are now in successful operation with fifteen-ton grabs.

After the grab bucket is raised out of the hold the truck which carries the walking beam is traversed inland until the grab comes over to one of two or three alternative points of discharge. Two of these deliver directly to railroad cars on tracks running between the legs of the Hewlett. The other is a small retaining hopper running on wheels which travels on the landward cantilever extension of the machine.

In case stock piling is to be done the grab bucket discharges into this traveling hopper, which then runs out on the cantilever and discharges on the stock pile. If more stock pile room is desired than can be reached by the cantilever, then a traveling bridge is brought into play precisely as described for the Hoover & Mason apparatus. The photograph (Fig. 11) on the preceding page shows the hold of a vessel with the grabs of two of these unloaders at work cleaning up its floor. No hand work has been done in this hold, yet it will be seen that the floor is almost as clean as if it had been swept, except for the piles on which the buckets are still operating.

Fig. 12 shows one of these Hewletts complete, though not provided with a long cantilever extension, but with a bridge in the background to do the stock piling.

Fig. 13 shows three Hewletts working on a vessel with the piles of ore at their landward ends, and the outer end of the bridge, which is making the stock pile, in foreground. Fig. 14 shows four Hewletts working on a steamer with stocking bridge behind them.

The absolute control of the mechanism which the operator exercises by having it rigidly supported instead of swung, and by the fact that he himself is immediately upon the bucket and can see to control its movements accurately, gives this machine advantages in handling bulk cargoes not enjoyed by any other type of machine. One of these advantages is that this accurate control of the grab bucket enables the operator to avoid striking the bottom of the hold severe blows

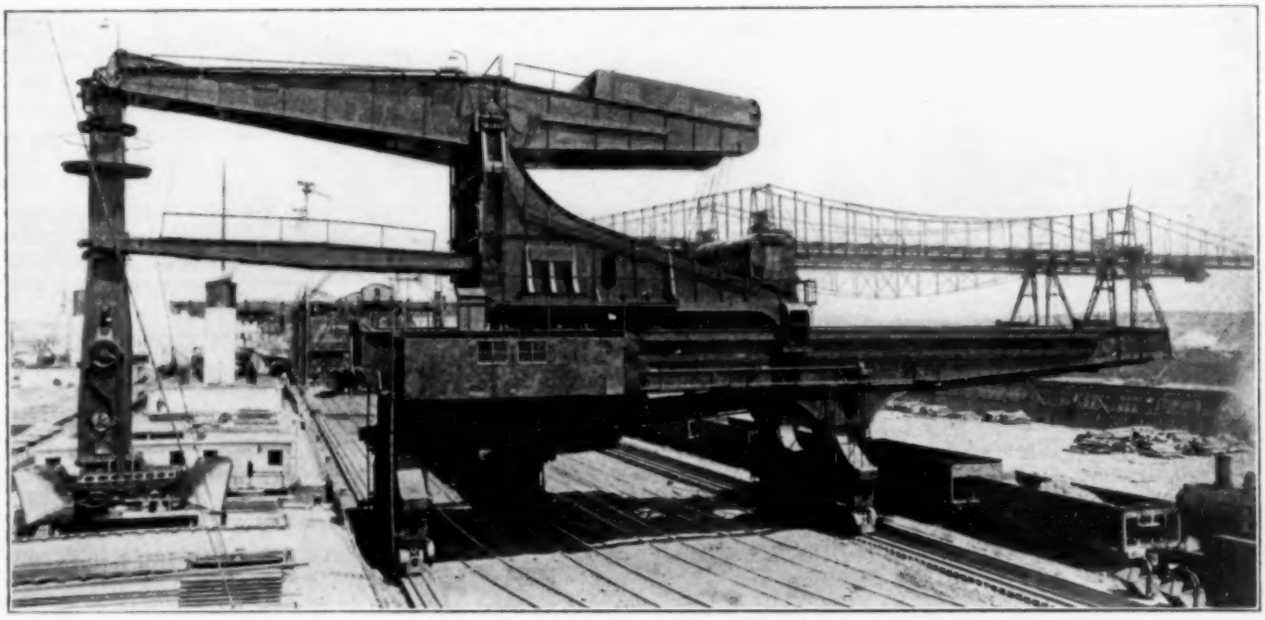


FIG. 12—HEWLETT COMPLETE

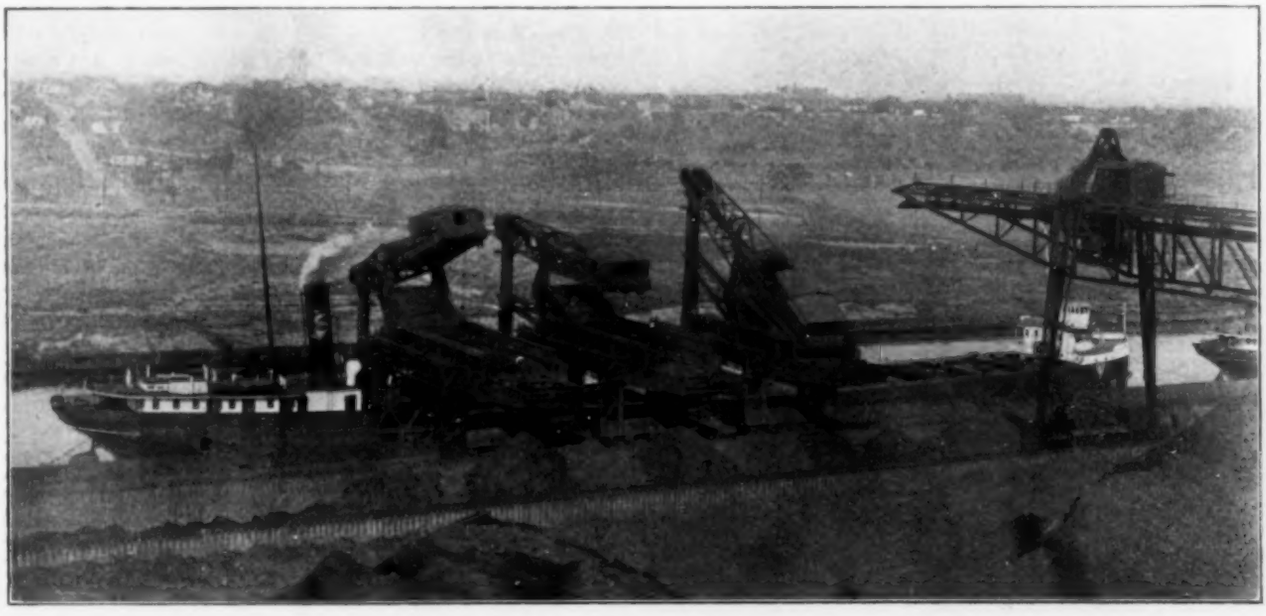


FIG. 13—THREE HEWLETTS WORKING ON A VESSEL, WITH THE BRIDGE MAKING THE STOCK PILE

with the bucket, as frequently happens with older types of apparatus.

In reclaiming the ore from the stock pile for use at the furnace the operation is very similar to that of stock piling. But in this case also it is necessary to provide some more easily movable means than the bridge itself for carrying the ore from the bridge to the point of consumption. It will be readily understood that there are always several, and maybe very many varieties of ore in the stock pile, and on account of the great difficulty in keeping these separated, the same kinds of ore are always piled together, so as to make the individual piles as few in number and as large as possible.

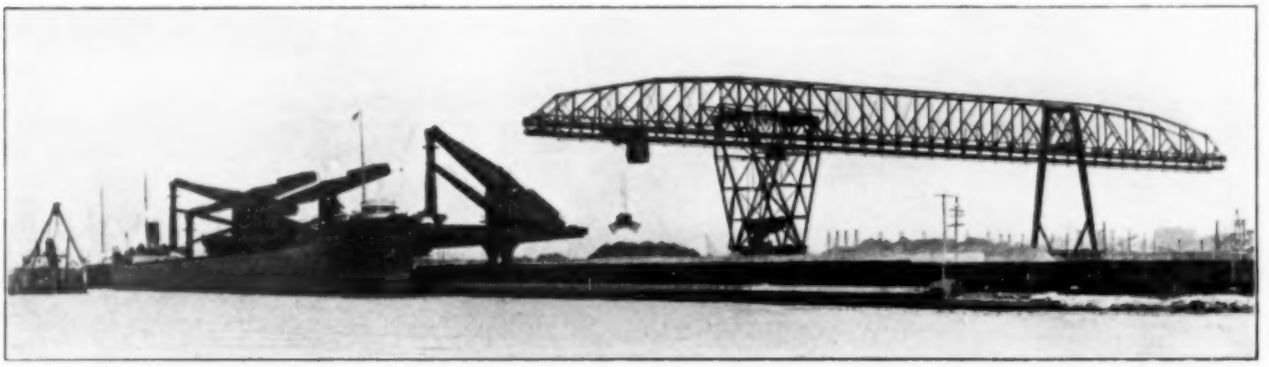


FIG. 14—FOUR HEWLETTS WORKING ON A STEAMER WITH THE STOCKING BRIDGE BEHIND THEM

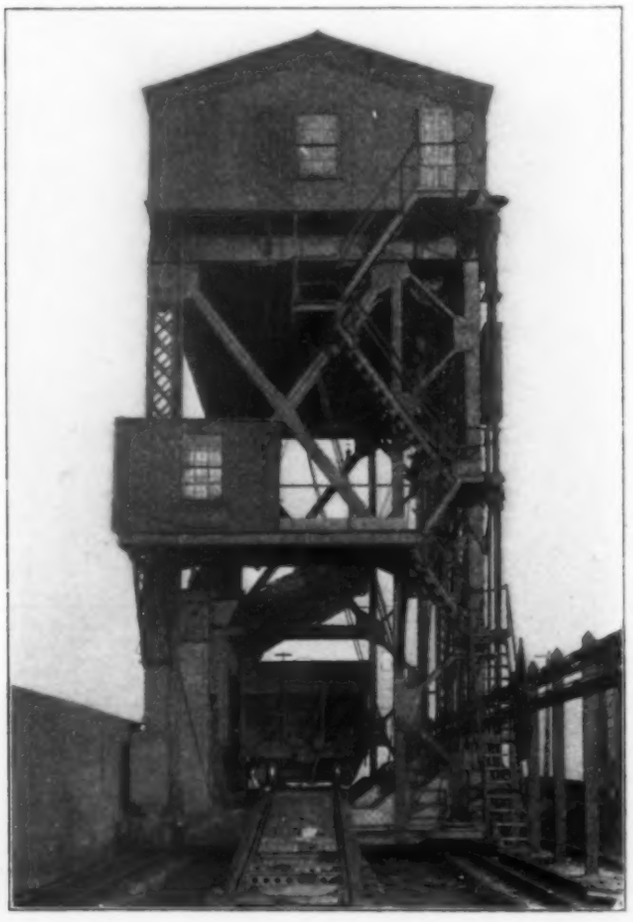


FIG. 15—CAR DUMPER

When any given kind of ore is desired for the furnace therefore, the ore bridge is moved over this pile and the grab bucket set to work on it. At the furnace or discharging end of the bridge it spans at least one and generally several tracks. Each traverses the tops of the bins from which the immediate supplies of raw materials are drawn. On one or more of these tracks runs a drop bottom transfer car, generally driven by an electric motor under the control of its operator. Such a car can carry fifty or more tons of material at a trip. The distance from the bridge to the bins where the ore is needed being only a few hundred feet, it can readily run back and forth from bridge to bins, and serve the bridge about as fast as the latter can reclaim the ore.

Many variations of this general plan of operation have been worked out. In some places removed from the Lakes the ore is received in drop-bottom cars, which are dumped from trestles, and the ore then reloaded as needed, either by taking the furnace-filling equipment direct to the stock pile and there loading it by hand, or by reloading the ore with clam-shell buckets, operated by locomotive traveling cranes, loading it into cars on the trestles, taking these to the bins and dumping

Car Dumpers

Plants removed from the lake shore must, of course, receive their ore by rail, and the enormous quantity to be handled in the relatively brief open season has made desirable in some cases a greater speed in dumping than can be secured even with the modern drop-bottom type of ore car.

To meet this condition an apparatus called a car dumper has been applied at some plants. This apparatus has been built in two styles, stationary and moveable. The moveable type is greatly to be preferred, because when a stationary dumper is used some style of transfer car is needed to carry the ore from the car dumper to the stocking bridge, which must stand in the location at which it is desired to stock the ore. With the traveling type of car dumper this is not necessary. The car dumper is moved along on its own tracks, just in front of those carrying the rear end of the bridge, and the car when dumped delivers the ore to the exact spot where it is most easy for the bridge to pick it up.

The general appearance of the car dumper, just back of the retaining wall of the ore yard, with a car standing in it, is well shown by the photograph, Fig. 15.

This apparatus can easily dump one hundred and fifty cars per day of ten hours, and most of the cars used in this service carry about fifty-five gross tons. It will be seen that the amount of material which can be handled through it in a given time is enormous.

In spite of the enormous capacity and great efficiency of these machines for the purpose intended, it may be doubted whether very many plants require the dumping of so vast a quantity of ore in a given time as to compensate for the heavy interest charges on the invest-

ment involved in one of these machines, especially in those cases where the ore yard is provided with elevated tracks from which dumping may readily be done.

In such a case the amount of labor involved in dumping the desired number of cars of ore from modern drop-bottom cars is not great, and its cost in all probability does not offset the interest and amortization charges on a car dumper.

At those plants in which the location of the ore yard is relatively high, and it is impractical to provide an elevated dumping trestle, the car dumper undoubtedly furnishes the best solution of the problem when considerable tonnages are to be handled.

Power Used

Various kinds of power have been used from time to time for operating the various types of ore-handling machinery, described and illustrated above, but it is safe to say that at the present time no power is seriously considered for this service under any ordinary conditions except electricity. This is supplied either from trolley wires or from sliding contacts, like a third rail, parallel to the track, as the circumstances may require.

Whether alternating or direct current is to be used is a matter of some discussion among experts in this field, but in the majority of cases direct current at 220 volts is used, because of the superiority of control which the direct possesses over the alternating, and because with this kind of current dynamic breaking can be used in addition to mechanical brakes for retardation of the moving parts. This can not so easily be done with alternating current.

Each plant presents ore-handling problems of its own, and in each case the problem must be worked out on the basis of the conditions to be met. Enough has been said to give a substantial idea of the general outline of the operation.

(To be concluded)

Synopsis of Recent Chemical and Metallurgical Literature.

Iron and Steel

Pulverized Fuel for Metallurgical Furnaces.—Supplementing an abstract on this subject in our last issue, we give a synopsis of a paper by Mr. JAMES LORD, published in the October, 1913, number of the *Proceedings* of the Engineers' Society of Western Pennsylvania. Mr. Lord gives the experience of the American Iron & Steel Manufacturing Company, Lebanon, Pa., of which he is president. This company has been using pulverized fuel at its plant, in experimental and practical ways, for the past ten years. "From the first it was apparent that its economical use depended upon the absolute control of the feed by the burner. This having been accomplished, we have applied it to over 100 furnaces of various types, such as those for puddling and heating, and of smaller sizes for re-heating nut, bolt and spike bars. It has proved to be a commercial success for all the above purposes, and the experience of ourselves, and others working along similar lines, shows that it can be used with equal economy for basic open-hearth steel furnaces, either with or without checker work. Our experience in the use of this fuel over a number of years has been so satisfactory and so economical that we are now largely increasing our installation, and are about to apply it to open-hearth steel furnaces."

Mr. Lord gives the following requirements for success with pulverized fuel: Both free and combined moisture in the coal must be less than 0.5 per cent; it must be pulverized fine enough to permit 95 per cent to pass a 100-mesh screen, and over 80 per cent to pass a 200-mesh screen; the delivery to the furnace must be controlled by the burner; the coal should have a high percentage of volatile combustible matter, not less than 30 per cent; the sulphur should not exceed 1 per cent.

The following figures show the pounds of fuel necessary to produce 1 ton of puddled bar, made from gray forge pig iron:

Furnace No.	April	May
23	1362	1318
24	1169	1277
25	1271	1472
26	1371	1362

The average for the same months on a lower grade of pig and cast scrap was 1239 lb.

The cost of preparing pulverized fuel during 1912 was as follows:

	Cents per gross ton coal produced
Fuel	0.034
Repairs to buildings	0.002
Operating	0.145
Power (steam and electric)	0.221
Repairs, machinery and equipment	0.200
Total	0.602

Analyzing the last item we find repairs which should be charged over a period of eight years, so that the total cost did not properly exceed 50 cents per ton of pulverized coal produced during 1912. If transmission is omitted, the cost of preparation would not exceed 40 cents.

In heating iron piles for rolling, the following quantities (pounds) of coal were used to produce a gross ton of rolled bars. On steel billets the amount would be one-third less:

Mill	April	May
12-in. Central	516	528
12-in. West	544	570
16-in. Central	519	523

The paper of Mr. Lord was widely discussed by many members of the society, who gave their experiences with pulverized fuel at different places.

Gold and Silver

Treatment of Gold-Bearing Scheelite in New Zealand.—The scheelite deposits of New Zealand are important sources of tungsten. One of the mines, the Golden Point, has been operated for twenty-five years, and is the principal producer. The ore contains gold as well as tungsten, and its treatment is interesting, as outlined by Mr. CYRIL W. GUDGEON in the *Australian Mining Standard* of Nov. 13, 1913.

The ore is sorted in the mine into first and second grades. On reaching the mill, the first grade is again hand-sorted, yielding from 1 to 2 tons per month of a product containing from 60 to 65 per cent WO_3, which is marketed. The reject from the hand-sorting is crushed and jigged, producing a concentrate of 60 per cent WO_3 and a tailing which is added to low-grade ore. The low-grade portion is crushed in stamps through 30-mesh screens, and run over amalgamated plates to recover some gold. The value of the ore usually averages $3.60 in gold, and of this $1.55 is caught on the plates. After amalgamation the pulp is classified and concentrated on Wilfley tables. The products are (1) a low-grade tungsten concentrate containing 30 per cent WO_3 and 60 per cent FeS_2; (2) slime tailing which is discharged, and (3) sand tailing which is leached with cyanide solution. The recovery in the cyanide plant is $1.30 per ton of ore. The low-grade tungsten concentrate amounts to only ½ to 1 per cent of the ore milled, and contains about 2½ oz. gold per ton. This material is then dried and roasted and subjected to magnetic separation for the removal of pyrite. The tungsten product runs 60 per cent WO_3; the pyrite con-

tains from 5 to 6 oz. gold per ton. The costs of milling 1998 tons of ore, in cents per ton, were: Breaking and jigging, 3.8; stamping, 55.8; concentrating, 8.0; general, 7.6; cyaniding, 26.6; magnetic separation, 36.0; total, $1.378.

Analysis and Assaying

Lead Determination at Broken Hill.—The *Proceedings* of the Australasian Institute of Mining Engineers, No. 10, 1913, contains an interesting report of the assay sub-committee on an investigation of methods used for analyzing and assaying Broken Hill ores and concentrates. The committee's investigations covered methods of estimating lead, zinc and silver. The samples were prepared by drying at a temperature not exceeding 200 deg. C., and then grinding to pass a 100-mesh screen. The sample thus obtained was rolled on a cloth and finally brought into a cone and flattened. Portions for assay were dipped from the mass with a spatula.

Lead.—The methods considered were (1) the molybdate, with two modifications, (*a*) filtering the lead sulphate hot and (*b*) filtering it cold; (2) the chromate, and (3) the gravimetric, weighing as lead sulphate. The general principles of these methods are all well known. Two methods of standardizing were tested, using metallic lead and lead sulphate. For the case of hot filtration in the molybdate method, lead sulphate cannot be used for standardizing, as similar conditions would not obtain in treatment of ore and standard. The accompanying table shows the results of tests made by different assayers (A, B, C and D), with all methods and modifications, determining lead in various ores and concentrates.

Table A

Ores	Ammonium-Molybdate Method. Filtering Cold: Pb Foil Standard				Ammonium-Molybdate Method. Filtering Cold: $PbSO_4$ Standard			
	A	B	C	D	A	B	C	D
Jig concentrates	76.2	76.6	76.6	—	76.0	76.3	—	76.0
Vanner concentrates	51.0	51.4	51.3	51.2	50.8	51.2	—	50.8
Crude carbonate	30.0	30.2	30.2	30.2	30.0	30.1	—	29.9
Crude sulphide	17.2	17.5	17.2	17.1	17.2	17.4	—	16.9
Zinc concentrates	7.5	7.6	7.5	7.5	7.5	7.6	—	7.4

Ores	Ammonium-Molybdate Method Filtering Hot Pb Foil Standard				The Dichromate Method				The Gravimetric Method			
	A	B	C	D	A	B	C	D	A	B	C	D
Jig concentrates	76.2	76.8	76.8	76.5	76.1	76.2	76.4	76.5	—	—	76.4	—
Vanner concentrates	51.1	51.4	51.4	51.0	50.5	50.7	51.2	50.3	—	—	51.1	—
Crude carbonate	30.1	30.2	30.2	30.1	29.8	30.1	30.1	29.9	—	—	30.0	—
Crude sulphide	17.4	17.4	17.2	17.1	17.0	17.1	16.9	17.1	—	—	17.2	—
Zinc concentrates	7.5	7.6	7.5	7.5	7.5	7.4	7.4	7.5	—	—	7.4	—

The table shows closely concordant results. When $PbSO_4$ is used as the standardizing agent, the results average 0.3 per cent lower in total lead than when metallic lead is used, due to the fact that lead sulphate is slightly soluble in the menstruum. When metallic lead is used this error is compensated, for the same solubility occurs in the case of both standard and ore. The results of hot filtering give slightly high results, probably due to the fact that the standard is high, due in turn to a slight solubility of lead sulphate in hot solutions.

The chromate method was not recommended by the committee because "it requires two filtrations and the use of two standard solutions, which greatly increases the amount of manipulation." (The chromate method tested is not that of Low, which is gaining favor in this country.)

The gravimetric method is suggested as being useful for purposes of checking the results of the molybdate method.

The molybdate method is recommended. Standard ammonium molybdate solution contains 8.8 g. of the C. P. salt dissolved in 1 liter distilled water. Tannic acid indicator is made by dissolving 1 g. tannin in 300 cc. distilled water, to which 5 cc. glacial acetic acid is added as a preservative. Ammonium acetate solution is made by mixing 2 liters each of ammonia and distilled water, adding 2 liters glacial acetic acid and making faintly alkaline.

The solution is standardized by either lead sulphate or metallic lead; if the latter is used, the precipitate is to be filtered cold. The calculation of the standard, and of the amount of ammonium molybdate necessary to affect the indicator, is made as follows: Make two titrations on different quantities of lead or lead sulphate; subtract the lower quantity from the higher, and the corresponding lower burette reading from the higher. Calculate the standard from the remainders, thus getting the true standard, exclusive of the indicator. The amount of solution necessary to affect the indicator is then found by dividing the standard found into either of the weights of lead taken, which will give the number of cc. of solution required at that standard. The number of cc. found first by calculation is subtracted from the number of cc. found by titration, and the difference will be the quantity required by the indicator. This amount is to be subtracted from each burette reading on an assay before multiplying by the standard. Thus.

Lead taken	Burette reading, cc.
0.3549	35.3
0.1575	15.7
0.1974	19.6

0.1974 ÷ 19.6 = 0.010071 g. of lead—the true standard
then 0.3549 ÷ 0.010071 = 35.24 cc.;
therefore 35.3 — 35.24 = 0.06 cc., which is the quantity required to affect the indicator, and which should be subtracted from a burette reading before applying the standard.

In the presence of large amounts of lime the method is modified by precipitating the lead from its ammonium acetate solution with ammonium sulphide, filtering, dissolving in nitric acid, evaporating nearly to dryness, neutralizing with ammonia, adding 30 c.c. ammonium acetate and titrating.

When antimony is present, carry the assay to the lead sulphate stage as usual, then dilute with water and add Rochelle salt to dissolve the antimony. Filter, wash and treat the lead sulphate as usual.

When tungsten is present, decompose the ore *thoroughly* with HCl; then add HNO_3 and evaporate to about 5 cc. Dilute with 80 cc. hot water, filter and wash with boiling water. Treat the filtrate with H_2SO_4 and proceed as usual.

Fuel Oil.—Circulars 140, 141, and 142 of Messrs. Tate, Jones & Co., Inc., of Pittsburgh, Pa., deal with fuel oil. Circulars 140 and 141 describe this firm's appliances for handling and burning fuel oil, circular 142 gives fuel oil data from actual experience. One big advantage of oil as a fuel in boiler work, whether marine or stationary, is the fact that with oil the boiler can be pushed way beyond its rating and an evaporation obtained that would be impossible with coal. "Recent tests made by the U. S. Navy Department show that the heat-absorptive power of boilers is very great and that boilers can be pushed with little drop in efficiency far above their normal rating. The evaporation per square foot of heating surface has been increased from 3 lbs. of water from and at 212° to 15 lbs. of water with a drop of efficiency of only 10%." Data are given on the use of fuel oil in furnace work—direct-fired, reverbatory, regenerative, and crucible furnaces, also kilns, etc.

New York Meeting of the American Institute of Chemical Engineers

Report of the Proceedings and Abstracts of Papers

The sixth annual meeting of the American Institute of Chemical Engineers was held in New York City from Wednesday, December 10, to Saturday, December 13, the headquarters being at the Chemists' Club, where all sessions were held. The attendance was particularly good.

At the business meeting held on the morning of Wednesday, Dec. 10, the result of the annual election of officers was announced as follows:

Professor M. C. Whitaker, of Columbia University, is the new president.

Dr. A. C. Langmuir was elected a vice-president; Dr. John C. Olsen, of the Polytechnic Institute of Brooklyn, N. Y., and Dr. F. W. Frerichs were reelected secretary and treasurer respectively; Mr. H. M. Kaufmann was elected auditor and Messrs. Henry Howard, John C. Hebden, and I. P. Lihme directors of the Institute.

M. C. WHITAKER, PRESIDENT AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

Sanitation Control of the City of New York

In the professional session which followed, the first paper was presented by Dr. **Ernst F. Lederle**, Commissioner of Health of the City of New York, who extended the city's welcome to the Institute in behalf of the Mayor, and then discussed in a very interesting manner the sanitary control of the City of New York by the Department of Health, showing by lantern slides many views of the "yearly clean-up" which was attempted for the first time in 1913 in New York City and the methods of disposing of the immense quantities of various refuse collected from the streets and houses. The lecture was profusely illustrated by lantern slides.

Recent Developments in Commercial Explosives

A paper by **Mr. E. A. Le Sueur** gave a sketch of the recent trend in explosives development. The most striking feature among the changes occurring in the field is the almost omnipresence of nitrate of ammonia. Although a salt of a hypothetical metal it breaks down into a gaseous mixture containing a surplus of free oxygen and no solid residue whatever and, insofar, is therefore peculiarly suited to employment in explosives. Unfortunately it is very hygroscopic and of deplorably low specific gravity so that but a comparatively small weight can be packed into a given cavity. On the other hand, its adaptability, within the above limitations, is remarkably wide, and it is associated with almost every ingredient known to explosives manufacture, and especially with nitro-glycerin. So wide is the present market for this material for use in explosives that practically the entire output of the gigantic Norwegian atmospheric nitrate works is now delivered in the form of nitrate of ammonia, and further important developments in the cheap manufacture of this compound are to be looked for in the very near future.

Perchlorates, and especially perchlorate of ammonia, have numerous advocates among the inventors, but so far do not appear to have entered the market to any very great extent. Perchlorate of ammonia is obviously, from its chemical formula (NH_4ClO_4) well adapted to act as an explosive itself and at the same time provide three atoms of excess oxygen to combine with additional material. Aside from any other considerations, it possesses the serious defect of liberating considerable hydrochloric acid or a mixture of the same with chlorine. The use of certain powdered metals in the mixture serves very largely to eliminate both of the above gases.

A most profound impression has been made in the explosives trade of late years by the nitro derivatives of toluol, and especially by the various commercial mixtures of di- and tri-nitro-toluol now on the market. The cheddites (practically mixtures of the higher nitrotoluols with chlorate of soda and a vegetable oil, preferably castor oil) have achieved considerable well-earned popularity, and the flood of current patent applications for explosives containing tri-nitro-toluol reminds one of nothing so much as of that which occurred some ten years ago for acetylene generators.

Bearing in mind that tri-nitro-toluol possesses certain of the properties, so far as explosive effects go, of nitro-glycerine itself; that it withstands water and is not affected by cold, and that it can be handled with absolute safety until blended with other materials that may increase its sensitiveness, it is not difficult to understand the enthusiasm with which it has been received by amateurs as well as by others in the explosives field. Aside from any admixture with other materials it forms, in the refined condition, an explosive of quite ideal properties for use in shells, torpedoes, mines and the like. In spite of its fierce and terrific disruptive energy and of an enormous speed of detonation, it is a safer material to handle, transport and store than, for instance, ordinary calcium carbide.

And, notwithstanding its inert behavior, it can be depended on absolutely to explode completely when exposed, in a suitable physical condition, to detonation from an adequate primer. Several European governments are now making extensive use of this intensely interesting compound. Owing to the fact that its constitution ($C_7H_5N_3O_6$) presents too little oxygen to combine completely with the carbon contents even to the monoxide form the result of explosion is the formation of a cloud of carbon particles which will presumably have its advantages in warfare both through marking

the position of a shell at the instant of explosion and by obscuring the enemy's vision.

The liquid nitro-toluols are also finding an important use in connection with nitro-glycerine. They greatly lower the freezing point of the latter, contribute their quota to the explosive effect, and render the resulting explosive much safer than before.

In addition to the above compounds and many others (including the nitro-napthalenes, benzenes and xylols) the old stand-by, chlorate of potash, holds its own as a prime constituent of modern disruptive powders. It may be worth while to glance for a moment at the extraordinary thermo-chemistry of the chlorates and perchlorates, the same having a vital bearing on the matters of energy developed, sensitiveness and stability of certain explosive mixtures containing them.

Chlorate of potash disengages heat energy to the extent of 93,800 calories per kilogram molecule on formation from its elements, but potassium chloride disengages 105,700 calories, or 11,900 *more* than the chlorate. The addition of three atoms of oxygen to the chloride is accompanied by the absorption of energy to this latter extent, the formation reaction being endothermic. Perchlorate contains one-third as much oxygen again as chlorate, but instead of the addition being accompanied by a further absorption of heat, there is actually a disengagement of energy, accompanying the entry of this lone atom, of far more (19,900 calories altogether) than the entire amount absorbed when the first three atoms were added.

Chlorate stands ready to fall to pieces on scant provocation and, in doing so, give up not only three atoms of active oxygen to any combustible in the neighborhood, but 11,900 calories per kilogram molecule as well. Perchlorate, on the other hand, in spite of its higher degree of oxygenation, requires more energy to drag it to pieces than does the chloride itself, and, in consequence, forms a less sensitive and less energetic constituent for an explosive than the less oxygenated chlorate.

In the light of the above, and especially in view of the fact that the besetting trouble with most modern chlorate explosives is lack rather than excess of sensitiveness, it will be seen that plain chlorate presents certain large advantages over perchlorate for many explosives. This will help to explain the fact that, although modern electrochemical methods enable the ready production of perchlorates, the latter have not, so far, become serious competitors in the field of commercial explosives.

Mr. Le Sueur then dealt at some length with a chlorate explosive developed by himself and which has come into widespread commercial use.

In manufacturing this powder five parts of paraffine wax are melted and four of ground sulphur and twenty-two of nitrate of soda stirred into it; the mixture is allowed to cool and is then grained. The resulting material is called "mineral base." In spite of containing an oxidizing agent and combustibles it is completely inexplosive technically. It is finished to explosive by dusting 8 parts (to the above 31 of base) of powdered chlorate of potash over the grains.

The final material possesses a number of interesting features. Due to an extremely low speed of detonation it develops its power in a way peculiarly available for the requirements of many large applications such as heavy rock work, clearing land of stumps and the like; and, owing to the said low speed of detonation, its high effectiveness for these purposes, even compared with explosives possessing decidedly greater energy content, is quite surprising. Its insensitiveness is such that it withstands the impact of a steel tipped service rifle bullet fired from the regular service rifle with a standard charge behind it without response of any kind; although, due to its property of going out after being set fire to when the flame causing ignition is removed, it is possible that incipient ignition occurs during the passage of the bullet.

If packed hard it is impossible to explode it by any means whatever. On the other hand, loaded loose, it is an absolutely sure fire with a No. 6 detonator even when unconfined, and, for work in earth, as in removing stumps, it is necessary to bear in mind that confinement may be negligible. When well confined in large shots in solid rock, and especially if detonated with a stick of dynamite, it will withstand any reasonable amount of packing and still give a sure fire.

From its composition it will be obvious that it is non-freezing, and, indeed, owing to the paraffine wax incorporated in it becoming harder with increasing cold, it loses its porosity through being pressed into holes less readily cold than otherwise. With regard to stability, it withstands the international stability test (75 deg. C. for 48 hours) with indifference, whether with moisture added or not, and some millions of pounds have been used during the past seven years, and in some cases excesses over requirements have been stored by contractors in badly constructed magazines, occasionally for years, and there has never been any sign of heating or decomposition, incipient or otherwise.

The very low chlorate content and the fact that all the other materials are used in their crude commercial condition, together with the extremely simple process of manufacture, render the cost of this powder exceptionally low. It is known under the name of R. R. Virite.

With reference to the property which this explosive, in common with very many others, has of being more difficult to explode as its porosity diminishes, Mr. Le Sueur points out a certain important corollary which exists in a case where the insensitiveness when closely packed reaches the point it does in a case such as the one under discussion. If compressed forcibly to a specific gravity of about 1.45 it has been found impossible to explode by any amount of detonation, no matter what the degree of confinement. This in spite of the fact that a certain small amount of local combustion occurs where the material is in direct contact with the detonator.

The superficially paradoxical situation confronts us that the only condition in which the material can be exploded by hammering between hard surfaces is one in which it becomes insensitive to detonation from another explosive. By this is meant that, in order to cause explosion of the powder by hammering, it has to be packed to a maximum density before the pinching between hard surfaces necessary to cause explosion occurs. Of course, what happens when the material is hammered on an anvil is that any excess over what can be pinched down to the thickness of thin paper between hammer and anvil is forced aside and only the trifling amount of powder actually so pinched goes off, and it has hitherto been found impossible by any degree of practicable impact to communicate explosion from the quantity so pinched to the rest of the mass of powder. The importance of this peculiarity in securing freedom from accidents in any case other than where the powder is exposed to detonation from another explosive is obvious.

If we consider what is the fundamental difference between the blow of a hammer and that of a detonator we see at once why a mass of the explosive which refuses to transmit detonation however powerful (within the enormous upper limit experimented with) when in a dense (non-porous) condition, why such material may be readily exploded when in a porous condition by a detonator although a blow from a hammer can only have

a local effect. The point is that, in the former case, the blow is struck so quickly that the explosive is hammered between the products of explosion of the detonator and, if this expression may be used, its own inertia, without having time for its porosity to be interfered with. The passage of a bullet exposes it to the same kind of a blow against its own inertia, but the swiftest bullet is so far inferior in speed to the velocity of the products of explosion of a detonator that it falls short, in the case of a powder of the class under discussion, of producing an explosion. There is also, of course, the essentially important feature, in the case of explosion by a detonator, of exposure to vastly greater heat than from the friction of a bullet or impact of a hammer.

The well-compressed material behaves, as previously stated, in a completely inert fashion to attempts to detonate it, but mere crumbling restores it to the explosible condition. It would seem as though a technical division on the lines of classification according to safety might well be adopted to embrace explosives that require outside detonation from another explosive in order to set them off.

Mr. Le Sueur finally discussed liquid oxygen as a constituent of explosives. Modern methods exist for producing this element in a state of high technical purity in the liquid form at a cost extremely low compared with its cost in the combined form in any of the chemicals employed in the explosives trade. So that completely smokeless and fumeless mixtures equal to 75 per cent dynamite can be made at a cost of about 2 cents per pound. As regards safety, explosives containing liquid oxygen stand in a class by themselves in one particular, *i. e.*, in the fact that, should a shot be missed for any reason, the charge presently becomes inexplosive through volatilization.

Of course, this is merely the merit which accompanies the greatest defect of these explosives. They must be used within a few minutes of being compounded. Nevertheless, this is by no means the absolutely prohibitive feature that might be expected, owing to two considerations, one of the numerous gigantic individual blasts that are necessary on certain heavy construction works (the time required for the charge to evaporate being comparatively long in such cases) and the other the fact that the addition of the liquid oxygen to the combustible portion of the charge may be made the last thing before firing. Mr. Le Sueur is rather firmly of the opinion that in the heaviest construction works of the future, especially where the so-called "coyote" shooting can be employed, liquid oxygen will play an important part.

In conclusion Mr. Le Sueur referred briefly to the hopes of the nitro-glycerine manufacturers that in synthetically prepared glycol may be found the solution of their bondage to the fluctuation of the corn and cotton seed crops. The production of glycerine depends considerably on the abundance or otherwise of pork and of cotton seed oil and the former depends largely on the corn supply. The stearine candle industry, another feeder to the high explosives maker, is not in a healthy condition, and altogether the situation of the dynamite manufacturers is not so completely free from anxiety in the matter of their glycerine supply as they might wish.

Dr. **W. M. Grosvenor** then presented briefly his suggestions on a "practical road to a standard catalog" of products of manufacturers for the chemical industries.

Presidential Address

In an evening session on Wednesday, held again at the Chemists' Club, the retiring president of the Institute, Dr. **T. B. Wagner**, presented an admirable address on the effect of legislation upon chemical industries.

This address is printed in full elsewhere in this issue.

The Clam-Shell Filter Press

A paper on the Sweetland clam-shell filter press was presented by Mr. **E. J. Sweetland** and illustrated by numerous lantern slides and demonstrations of a working model. We herewith give Mr. Sweetland's paper slightly abstracted.

That there is great room for improvement in the methods of filtration commonly employed cannot be doubted. The plate and frame filter press ordinarily used comprises anywhere from forty to one hundred filter chambers each of which must be cleaned individually by hand every time the filter is filled.

It was to eliminate the excessive amount of hand labor in cleaning filter presses that the filter under discussion was primarily designed, but as the construction was developed many incidental advantages of importance developed with it.

The single advantage in plate and frame filter presses that has kept them in favor is the fact that their peculiar construction affords a very large filter area in a comparatively small space. Filtration cannot be forced beyond a certain reasonable limit, when this limit is reached it is necessary to increase filter area to increase capacity. To endeavor to increase capacity by increasing pressure instead of filter area is futile, for excessive pressure merely presses the cake to a compact, almost impervious layer, and the object is defeated at once.

With this in view, the modern filter must not depart from a construction that permits of ample filter surface. Other things being equal, the capacity, and consequently the value, of a filter is proportional to the filter area.

The sluicing type of filter press is one example of a filter press construction that eliminates hand labor in cleaning. In this type the cake is disintegrated by a stream of water forced into each chamber. The cake thus liquefied flows to the waste reservoir, or dump. The usefulness of this method is limited for obvious reasons, principal of which is the need of recovering the cake as dry as possible in most processes.

The uses of filter presses are so varied that great flexibility is required. To be a commercial success the modern filter press must lend itself to the various requirements which may come up, and the construction made adjustable as far as possible.

CONSTRUCTION

The Sweetland filter has become known as the "clam-shell" type, due to the shell being in two parts hinged together to open and close somewhat after the manner of the clam shell bucket used on steam shovels.

The filter body comprises two semi-cylindrical members hinged together, one member being provided with an inserted gasket which seals the joint between the two to form a water-tight cylinder when closed. Fig. 1 shows an end and side elevation of the filter in closed position.

A plurality of openings is provided along the top to receive the stem or outlet nipple of the filter leaves. These outlets are spaced quite close together, so that the leaves may be closely spaced if desired, as is the case when thin cakes are to be formed; but the leaf spacing may be increased to any degree by taking out part of the leaves and stopping off the intermediate outlets.

Variable spacing is quite essential, for it is not always possible to ascertain in advance exactly what spacing will be best suited to the material; and further, there is always the possibility of the process being modified to change the filtering properties of the material and make a change in leaf spacing desirable.

The filter leaves are usually made of wire screen, well crimped to provide ample drainage. The screen is bound at the edges to stiffen the construction and protect the cloth. An outlet nipple with a side opening furnishes an exit for the filtrate and means of holding the

leaf in the filter body. The filter cloth covers the entire metal construction of the leaf except the outlet nipple, and is held on either with metal clips or by being stitched around the edges.

The leaves are held in place in the filter by a cap nut which engages the top of the nipple and draws the shoulder of the leaf tightly against the rubber washer which fits in a recess inside the filter body. The side outlet of the nipple aligns with the filtrate delivery fittings on the outside of the press.

Fig. 2, which is a cross section of the filter body clearly shows how the filter leaves are held in place by the nipple at the top. Each leaf has separate outlet fittings comprising shutoff cock, glass delivery tube, etc. These fittings allow the operative to see the filtrate from each individual leaf as it flows through the glass, and any leaf that might become injured or require renewal of cloth is indicated at once by a turbid filtrate in the glass. In this event the shut-off cock governing the defective leaf is closed until the filter is opened and the leaf replaced. To remove a leaf only the cap nut has to be removed—the outlet fittings are not disturbed.

In the earlier designs of this filter the two halves of the shell were held in closed position by hand operated swing bolts. These were fairly quick and convenient to operate, but still left room for improvement. It was desired to modify the construction to an extent that would reduce the time to unlock and open the filter from a few minutes to a few seconds, if possible. This was accomplished by a very simple change in the construction. The hinges, which formerly took no strain while the filter was in locked position, were increased in strength and number and made to take the strain formerly taken by the swing bolts on the back of the filter body. To eliminate any possibility of breakage, the hinges are made of steel, which can be fully depended upon for strength.

What seemed the great problem in working out this improvement was the need of accurate hinge adjustment to take up wear in the gasket. This problem like many mechanical problems proved to be simpler than was anticipated, for it was solved by simply making the hinge pins into one continuous shaft reaching from end to end of the press, and turning the bearing which received all of the hinges on the upper member eccentric to the normal axis of the shaft. This construction not only affords adjustment, but makes adjustment of all hinges simultaneous by simply turning the hinge shaft slightly when adjustment is necessary to draw the upper and lower halves of the shell closer together as the gasket gradually flattens out from continued use. The shaft is held from turning by set screws, which are loosened when adjustment is made.

An eccentric shaft with swing bolts rests in babbitted bearings along the front of the upper half. Each bolt has an adjusting nut and lock nut for initial adjustment and for taking up wear. The swing bolts are tightened or loosened simultaneously, due to the eccentricity of the shaft, when the latter is turned through an arc of 180 degrees, and means is provided of swinging the bolts clear of the lugs on the lower half just at the point when they have loosened sufficiently to disengage themselves.

This arrangement makes it possible to open or close a filter press of moderate size in a few seconds. The lower half of the shell is poised with counterweights to facilitate opening and closing. A sectional view, showing hinges, eccentric shaft, etc., is shown in Fig. 26.

In large machines an eccentric shaft is used on both front and back, and a hydraulic cylinder operates the two simultaneously by means of a cross head and connecting rods. The lower member in this case is swung open and shut by a hydraulic cylinder at either end which is so arranged that the shell is opened so wide as to invert it and thus clean itself of any cake that might have fallen before it was fully opened.

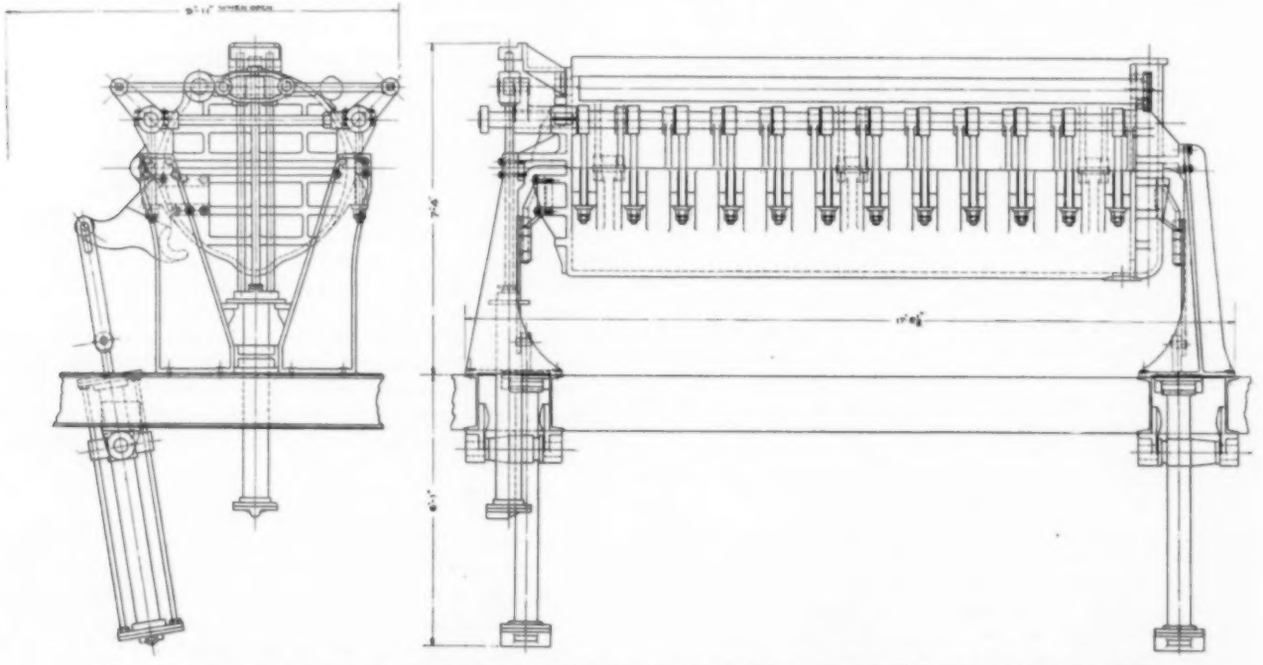


FIG. 1.—END ELEVATION AND SIDE ELEVATION OF CLAM-SHELL FILTER PRESS IN CLOSED POSITION

OPERATION

In operating the filter the liquid to be filtered is forced into the filter body under pressure, expelling the air and entirely submerging the filter leaves. The liquid filters through the cloth and deposits the suspended solids on the outside of the leaves, forming the "cakes." Filtration continues until the cakes on adjacent leaves are separated only by a narrow space which may vary in width from $\frac{1}{8}$ inch upward. When the cakes are formed to the proper thickness the wash water valve is opened and sludge valve closed simultaneously.

The wash water enters the space between the cakes forcing the small quantity of unfiltered sludge to de-

posit its solid component upon the cake surface. The space between adjacent cakes is now occupied by water, which being under pressure, percolates through the cakes, driving the strong liquor ahead and effectively displacing it until the cakes are washed to the desired degree, as indicated by frequent tests of the effluent.

Mr. Sweetland enlarged upon the subject of washing the cakes, for therein lies a great difference between his

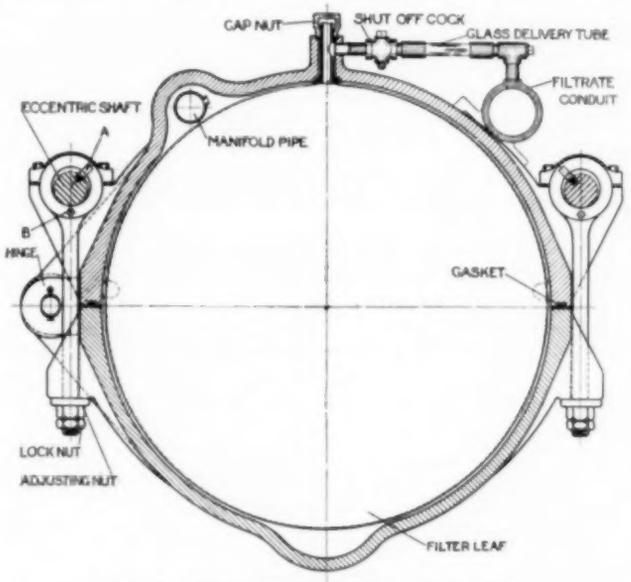


FIG. 2.—CROSS SECTION OF FILTER BODY

and other leaf filters. It should be noted that there are no chambers or containers to be packed solidly full of cake. The spaces between the leaves are not packed solidly full, but a cake is deposited on the surface of each leaf and these cakes are allowed to build up until only a narrow space remains between them, and in this space lies the secret of successful automatic discharging of the filter and efficient washing.

The cakes have been formed under equal conditions, the sludge being evenly distributed and the pressure equal throughout the filter chamber; therefore the cakes must be of even thickness and density, and must wash evenly. That this actually occurs has often been demonstrated by testing samples of the washed cake from various parts of the press.

All filters of the leaf type wash by "direct contact" methods; that is, the wash water is in direct contact with the cake; but the methods of washing that have heretofore been practiced with leaf filters, whether vacuum or pressure, are indeed anything but direct.

The usual method of forming and washing the cakes on filter leaves is as follows, assuming that the cake has to be washed first with weak liquor and then with water: Fill filter tank; deposit cake on leaves; withdraw excess solution; fill filter tank with weak solution; wash cakes with weak solution; withdraw excess weak solution; fill filter tank with water; wash with water; withdraw excess water; discharge cakes from leaves.

Here are ten distinct operations, which are still further complicated by the fact that the cakes will not cling to the leaves unassisted, but must be held on with either compressed air or vacuum during the time each quantity of excess is withdrawn. Mr. Sweetland did not dispute that the cakes can be washed well by this method, but raised the point that it is an extremely round-about method of accomplishing a simple object. Most of the power consumed is not devoted to filtration, but to transferring solutions, much of the time is not devoted to filtering, but to waiting for transfers to be made, and the operative is kept busy manipulating valves.

The delay in filtering necessitated by the many transfers materially cuts down the duty of the filter, and the process becomes a complicated one, requiring many tanks and much accessory apparatus to take care of excess solutions.

Nor is this all. The transfers of excess solutions referred to introduce other complications. The cakes must be supported upon the leaves at all times by pressure. Air pressure (whether produced by suction or otherwise) must be used during the transfers. If too much pressure is used, the cake will be cracked (due to the shrinkage of partial drying) and the wash water will "short circuit," that is, pass through the channels formed by cracking. If too little pressure is used, all or part of the cakes may fall from the leaves, which would preclude the possibility of efficient washing. Lastly, if the cakes are of a fine slimy character, the partial drying during the transfer packs the particles of slime, and makes it less pervious than ever to the passage of wash water.

The origin of the many complications cited above is traced directly to void or "dead" space in the filter tank or chamber which contains the filter leaves. If there were no dead space there would be no excess solutions, and consequently none of the complications which attend them.

The "clam-shell" construction of filter body has no void space. It contains nothing but the filter leaves and manifold pipe. When the filter leaves are loaded with cake the entire filter chamber is full except the feed channel for distribution along the bottom, and the narrow space between the cakes for the entrance of wash water. There is, therefore, no excess solution to handle. Filtration is continuous from the time cake forming is commenced until washing is finished, and the process of filtering and washing is reduced to the simplest possible terms.

When washing is finished the cakes are partially dried with compressed air, the lower half of the filter body is swung open and the cakes are dumped into a car or conveyor underneath. To assist the cakes to dislodge from

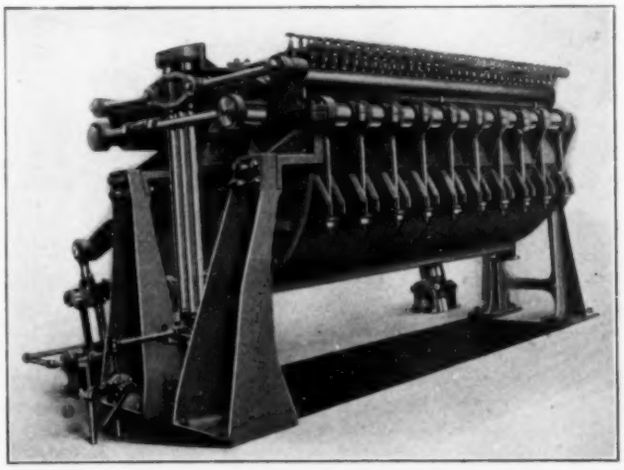


FIG. 3—HYDRAULICALLY OPERATED SWEETLAND SELF-DUMPING FILTER CLOSED

the leaves, the current is reversed by turning steam or compressed air inside of the leaves, which not only causes the cakes to drop off, but benefits the cloth by keeping the pores open.

For the benefit of those who insist that better washing can be obtained by draining the filter body before introducing wash solutions or water, Mr. Sweetland pointed out that the filter construction here described offers every facility for carrying out this method, if desired; but, after installing many of them, large and

small, under widely varying conditions, and seeing trials made both ways, he strongly advocates the direct method without withdrawing solutions.

If the material is very slow-filtering and the space between the cakes wide, then it is better to introduce the wash water through the manifold pipe and let the water entering the top fill the chamber by downward displacement, forcing the excess solution out of the drain valve at the bottom. The water being lighter than the sludge, it does not mix with it, but floats on top during displacement. In this case filtration is continuous, pressure is maintained in the chamber, no time is lost, and the cakes are constantly submerged.

Mr. Sweetland then discussed why the body of this filter was designed cylindrical instead of square. Obviously the principle could be carried out in a filter body of square or rectangular section. The reasons for cylindrical construction are: The cylindrical construction affords great strength, whereas any shape with straight sides would require so much reinforcement to give it the necessary strength as to make it cumbersome and awkward.

In the cylindrical construction the leaves are exposed to view by simply swinging the body open.

A circular leaf is conveniently supported from one point and is very strong and light.

If the chamber were square the leaves would be inaccessible, or else would have to be lifted out with the

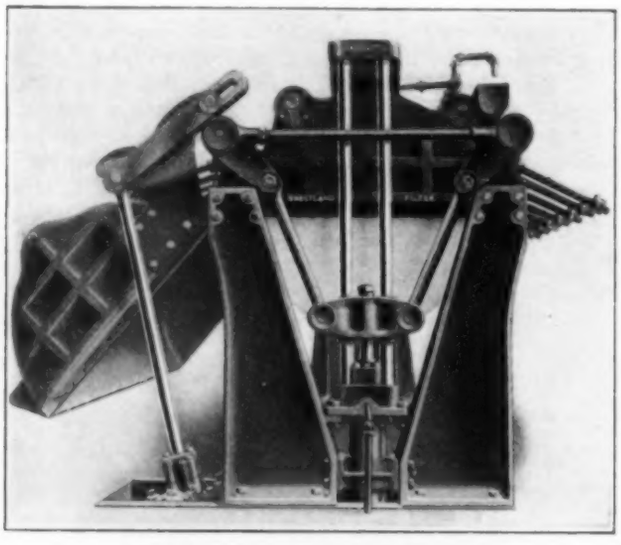


FIG. 4.—END VIEW OF FILTER OPEN

cover to discharge, and this would involve mechanical difficulties.

The circular form of leaf does not involve as much waste in filter cloth as might be imagined. There is to be sure a slight waste of cloth cut from the corners, but most of this has an important use in reinforcing the cloth at the edges of the leaf. On the other hand, a large percentage of the cloth used in plate and frame presses is not used for filtering, but to form a joint between the frames. If we figure it out in any case, we find that the percentage of cloth purchased that is utilized as filter medium is about the same in either case. In fact the cost of cloth per unit of work done is much less in the case of the leaf construction, because the capacity per square foot is greater, and the cloth is not injured by being squeezed between the frames.

As to filtering mixtures containing coarse particles, these offer difficulty in any type of filter, due to the coarse particles settling to the bottom, making the bottom of the cakes more porous than the top and resulting in uneven washing. The remedy for the trouble is to keep the contents of the filter chamber in a state of agitation. To accomplish this the feed pump is provided large enough to supply the necessary pressure for filtration with additional capacity enough to permit a restricted overflow to run from the manifold pipe back to the supply tank during filtration.

FILTER AIDS IN FILTERING MATERIALS CONTAINING A GUMMY RESIDUE

New light is being thrown on the subject of filtration with almost every new installation, and problems are being successfully solved that appeared at the start to be impossible of solution. To cite an instance: A sample of a heavy viscous liquid was submitted for test. It contained a gummy residue that blocked the filter cloth from the start, and the rate of flow of filtrate per square foot of cloth was but a few cubic centimeters per hour, and the cloth became so coated as to defy cleaning by any practical method.

As the solution only was required, and the residue was worthless, there seemed to be no objection to adding some inert granular substance to the liquid as an aid to filtration. A series of experiments was undertaken, adding various "filter aids" to the fluid, and the outcome of this work was that an average rate of filtration of three gallons per square foot of cloth per hour was obtained and the gummy residual matter was sufficiently broken up to permit the filter cloth to be readily cleaned by reversal of current. Upon completion of the tests, a filter was installed in the plant and has fully demonstrated the practicability of the method on a working scale.

It was found that any one of several substances could be used as an aid to filtration, among which are fine sand, fuller's earth, kieselguhr, sulphate or carbonate of lime, sawdust, wood pulp, etc.

It is not argued that such methods are applicable to all cases, but there are unquestionably many problems that will find solution in similar schemes, which make possible rates of filtration such as are usually obtainable only in sand filters, with the added advantage that the leaf filter offers an enormous filter area in a small space, combined with extraordinary ease of cleaning.

Another method of filtering materials containing a gummy residue that tends to choke the cloth is that of depositing a protecting layer on the cloth before commencing filtration. For instance, we may first fill the filter body with a very thin slurry of carbonate of lime and filter this mixture for a few seconds until a film of lime, say 1/32″ in thickness has been deposited. This coats the cloth as completely and evenly as a deposit could possibly be made. The lime slurry is then drained off and filtration commenced. The coating of lime forms a complete film between the cloth and gummy residue, so the latter never even touches the cloth. When ready to clean the cloth the reversal of current is effective, because the coating of lime breaks away readily.

It is frequently asked how we can tell when cakes of sufficient thickness have been formed, especially when the material filters and builds up the cake rapidly. This is not as difficult as would be imagined. The usual way is to work at a given pressure, say forty pounds per square inch, and pump for a certain number of minutes, determined by practice to form the required cake. Another way is to pump a certain number of inches from the supply tank for each charge. As in all processes, the operative soon becomes expert and can judge from the general conduct of the filter when the charge is sufficient.

The usual skepticism which attends the introduction of any new machine was encountered at first, but so many installations are now in successful use as to establish fully the usefulness of the methods described. A noteworthy point is the fact that many of the filters

of the type in use are of much larger size and capacity than it is found practicable to build filter presses. Many have been built with a capacity of 133 cubic feet of cake per charge and several others ranging from 80 to 120 cubic feet per charge. One especially large one was built which dumps over 25 tons of cake per charge.

That this apparatus is now far beyond the experimental stages is demonstrated by the fact that a large beet sugar factory in California installed three large hydraulically-operated machines for the 1913 campaign. They were installed almost at the last minute before the campaign started and were at once placed in service at full capacity, and no difficulty was encountered, in spite of the fact that none of the employees who operated the machines had ever seen one before. The time required to open, clean and close one of these filters is about five minutes, which minimizes labor to such an extent that one operative can take care of several large machines, even though each machine has to be cleaned hourly.

Electrolysis of Chloride Solutions with a Mercury Cathode

In a brief paper by Mr. **E. A. Le Sueur** reference was made to the author's well-known pioneer work on the electrolytic production of caustic soda and chlorine started in 1888. While in this work Mr. Le Sueur developed the diaphragm process, his first experiments in 1888 were made with a mercury cathode.

The point emphasized by the author is that with a view to getting the sodium the worst possible place is to deposit it on top of a layer of mercury exposed to contact with the solution. The point is that, although sodium dissolves in mercury, the initially formed amalgam is of very low specific gravity compared with mercury itself and naturally tends to stay on top of the latter. The alternative occurred to Mr. Le Sueur to use the under side of the mercury as the cathode, the upper side being completely exterior to the electrolyzer as such, with the idea that the sodium, as fast as it was delivered to the under side, would bob up to the upper side and be thereby removed from relation with the electrolyzer and its contents.

This he proceeded to do, using a horizontal square frame of paraffined pine wood, a supporting sheet of a special cotton fabric carried by the under side of said frame, and additional support supplied to the fabric by a paraffined wood grating. Mercury was placed on the fabric to a depth just sufficient to cover it completely and a current supplied from a primary battery of three large bichromate cells between a carbon anode and the under side of the mercury, saturated salt brine being the electrolyte. As far as it went this experiment was successful, and the author is convinced that this general principle would work up to the best possible type of mercury cathode electrolyzer.

"In the light of the principle so clearly grasped in connection with the above quarter century old work, it is curious to note, in Wilderman's address before the International Congress last fall, the repeated remarks on the disadvantages all processes previous to his have labored under of putting the light sodium on the top layer of mercury and leaving it there."

New Filter Press

The first paper of the Friday morning session was presented by Dr. **Alfred Burger** on a new filter press which appears to have some important advantages over the old chamber press. It is really a novel and very ingenious system of piping in connection with the filter press. The principle of washing is the same as in the Sweetland press, but the method is different and Dr. Burger's system can be attached to any chamber press. The following figures were given, the figures in row No. I referring to an old chamber press, those in row No. II to the Burger press, and those in row No. III to a filter press of the leaf type.

	Washing efficiency	Final H_2O left	Pound of dry mud per filterpress sq. ft. per hour
I	20%	30%	0.8
II	60%	28%	3.
III	54%	36%	3.5

Ozone

Dr. **A. Vosmaer** then presented a very interesting lecture illustrated by lantern slides on ozone, its manufacture and use. The paper consisted of three parts, dealing respectively with the methods of manufacture, the properties of ozone, and its uses, especially for sterilization of water, for deodorization of air, and the applications of ozone in the chemical industries.

Since Dr. Vosmaer is writing a special elaborate series of articles for this journal, discussing the subject in great detail, it must suffice here to refer the reader to these articles. The first two articles of this series appeared on pages 623 and 705 of Vol. XI, 1913, and a third article will be found elsewhere in the present issue.

In the discussion Dr. Franklin spoke vigorously on the stir caused by the recent agitation of medical circles against ozone. Their experiments as to the fact that ozone does not kill bacteria in air were perfectly right, but did not refute in the least anything that had been claimed by intelligent and reliable advocates of the treatment of air by ozone.

Wood Turpentine Industry

A paper on the status of the wood turpentine industry by **E. H. French** and **James R. Withrow** was then presented by Dr. Withrow.

This paper outlined the present status in this industry and compared the same with that of gum turpentine. Emphasis was laid upon reasons for past failures in the business and upon the fact of its economic necessity for the utilization of cut-over timber lands.

The various processes for producing wood turpentine which have been in extended use, namely, the steam, solvent, alkali, bath, and distillation processes were discussed, giving general data derived from commercial operations as to yields, value of products, cost of operation and construction. The advantages and future possibilities, together with the disadvantages of each process, were discussed, but no particular process was recommended to the exclusion of others. The conditions under which only each may operate with profit were indicated.

As many of these figures in this paper contain heretofore unpublished information the paper will be published in full in our February issue.

The paper was discussed at some length by Dr. Wagner and Mr. Chute.

Symposium on Welfare and Safety Work in the American Chemical Industries

In the evening of Friday the members of the Institute were the guests of the New York Sections of the American Chemical Society, the American Electrochemical Society, and the Society of Chemical Industry, the program being a symposium on welfare and safety work in American chemical industries.

Miss **Florence Hughes**, member of the general staff for sociological work of the New Jersey Zinc Company, gave a general outline of organization and development of neighborhood work at Palmerton, Pa., of the welfare work in progress at Austinville, Va., and De Pue, Ill., and emphasized the consistent policy as applied to safety and hygiene in care of workmen. Several conclusive statements were made as to relation between settlement work and the industrial and social problems.

Mr. **Howard Lyon**, of the experimental department of the Welsbach Company, discussed in his paper safe conditions of labor, fire protection, means for promoting the health of employees and treating the injured, the establishment of an employees' relief association, and provision for æsthetic and cultural betterment.

Mr. **Charles P. Tolman**, chairman of the Manufacturing Committee of the National Lead Company, dealt with sanitary improvements in the manufacture of white lead, both in the corroding yard and the mill, welfare equipment and welfare work, safety devices for the prevention of physical injury, and emphasized the human element in work of this kind.

Dr. **Francis D. Patterson**, director of the Department of Sanitation and Accident Prevention of Harrison Bros. & Co., Inc., spoke of the sanitary measures, devices and improvements, and the means for the prevention of accidents, adopted by this company.

Excursions

A very full program of excursions was provided which included a visit to the Barber Asphalt and Paving Company of Maurer, N. J., a whole-day excursion on Thursday to the plant of the Sanitary Utilization Company at Barren Island, with inspection of the Willard Park Hospital group of laboratories of the Department of Health of the City of New York, and excursions on Friday afternoon to the experimental electro-plating plant of Hanson & Van Winkle Co. at Newark, N. J., and the Atha Works of the Crucible Steel Company of America, at Harrison, N. J. On Saturday morning the chemical engineering laboratories at Columbia University were inspected.

The International Exposition of Safety and Sanitation, held under the auspices of the American Museum of Safety at the new Grand Central Palace, also attracted many members of the Institute.

A well attended and greatly enjoyable subscription dinner was held on the evening of Friday at the Chemists' Club, when the Institute medal was presented to Dr. Frerichs.

The place of the next meeting has not yet been determined, but it will probably be either Buffalo or Troy, N. Y.

Analyses of Coals in the United States

The report just issued by the United States Bureau of Mines as Bulletin 22, entitled "Analyses of coals in the United States, with descriptions of mine and field samples collected between July 1, 1904, and June 30, 1910," contains the analyses of 5000 samples of coal taken from 1500 coal mines and prospects situated in the various coal fields of the United States. Not only all of the important fields are represented, but practically all of the more important mining districts.

The purpose of the bureau in compiling and publishing this information is to present reliable information regarding the chemical composition and heating value of the coals. The samples of coals were collected by experienced men according to a definite and uniform system, and were analyzed under carefully controlled conditions, so that there might be no question as to the relative merits of the different coals so far as this can be determined by chemical analyses and determination of heating values.

An increasing proportion of the coal consumed in the power stations and the larger manufacturing plants of the country is now being purchased under specifications based on chemical analyses and calorimetric determinations of heat units. In the purchase of fuels many matters that have been left to chance are now carefully investigated.

It is the aim of mechanical engineers to construct furnaces and to arrange the heat absorbing surface in a furnace with reference to the peculiar character of the fuel which is to be burned. Noting the composition of the fuel and constructing the furnace with reference to it, he can assure efficient and smokeless combustion. Moreover, in any particular market, the choice of coal generally is limited by its quality and by freight rates to one or two fields in which the character of the coal bed is comparatively uniform.

Having on hand a representative analysis of the coal from a given bed in any particular district, the engineer can determine whether the coal he receives comes from the bed and the district stated, and whether it is being prepared for market as carefully as it should be.

Wide variations in the composition and heating value of the coals from different districts and from different beds make analyses that are comparable, because of the care taken in sampling and analyzing the coal, almost indispensable to engineers having to install boiler or gas-producer plants in different cities, and also to railroads and steamboat companies, and to the engineers and purchasing agents of the various departments of the United States Government.

The report just issued by the Bureau of Mines is in two parts, one giving the methods used in collecting and analyzing the samples, and the results of the analyses, and the other giving the exact location from which each sample of coal was taken, together with a description of the characteristic features of the coal bed at the point of sampling, the nominal capacity of the mine, and such notes on the preparation of the coal as might be useful to consumers.

The data contained in these two volumes is not equalled in scope and detail and in value for comparative purposes by the figures that have been published by any other coal-producing country in the world. The governments of some of these countries have published analyses of coals from different mines and from different districts, but, with few exceptions, the samples of coal were not collected and analyzed under a uniform system that would make the results comparable in all respects, and no country has attempted to publish such a large number of analyses that would be comparable because of the care taken in collecting and analyzing the samples.

Copies of this bulletin may be obtained by addressing the Director of the Bureau of Mines, Washington, D. C.

A Large Electric Steel Furnace Installation

The American Iron & Steel Company, of Lebanon, Pa., has just closed a contract with Siemens & Halske, of Berlin, Germany, through their representative, Dr. K. G. Frank, of New York City, for what will be the largest single electric furnace installation in the world.

The company has been making an investigation of electric steel-making in this country and Europe and has decided upon the construction of two 20-ton induction furnaces of the Frick type. The furnaces will be of double-ring type and will run on five cycles, single phase, and about 5000 volts. The power requirements will be about 1800 kilowatts each. Two new generators will be installed by the company to serve this need.

The Pacific Tank and Pipe Company have moved their San Francisco sales offices from Fifth and Bryant Streets to their old offices, which have been completely refitted, at 318 Market Street, San Francisco.

Fuller's earth is the subject of *Bulletin* 71, Bureau of Mines, and deals with the properties, production and preparation of the material for commercial use. Laboratory methods of testing the substance are given.

Recent Chemical and Metallurgical Patents

Copper, Lead and Zinc.

Hydrometallurgy of Copper.—The accompanying flow-sheet shows diagrammatically the process of Mr. FREDERICK LAIST, of Anaconda, Mont., for the treatment of low-grade copper ores and tailings, in which the metal may be in the form of oxide, carbonate, silicate or sulphide, or in any form in which it may be dissolved and precipitated by H_2S. This process has been devised for the treatment of sand tailings at Anaconda, and a commercial-experimental plant of 80 tons daily capacity is now in operation.

Some of the details of the process, as relating to sulphide ores containing copper and silver, are given herewith. The ore is first subjected to an oxidizing or sulphating roast in a McDougal roaster. The furnace is of special construction. The upper three hearths are devoted to the oxidizing roast, and the lower three to a chloridizing roast, about 1 per cent of salt being added. The resulting products are cupric chloride, silver chloride, ferrous chloride and ferrous oxide. In the chloridizing roasting process some of the copper passes off as fumes of copper chloride, together with some hydrochloric acid. These fumes are drafted to an absorption tower where they are absorbed in water and returned to the leaching solution.

The calcine resulting from the oxidizing and chloridizing roast is leached in vats with a solution of water with about 5 per cent H_2SO_4 and 10 per cent NaCl. This solution dissolves the metals, and contains copper chloride, copper sulphate, silver chloride, and certain impurities such as iron and aluminium sulphates and chlorides. The solution is then drained off and precipitated with H_2S, yielding a precipitate of copper and silver sulphides. The sulphuric and hydrochloric acids are regenerated and used again. To prevent the accumulation of iron and aluminium salts in the leaching solution, part of it is continuously run to waste.

Sulphuretted hydrogen as a precipitant has certain advantages over electrolysis, in that no expensive equipment is required, and its action is not affected by the ordinary impurities of the solution. The gas is generated from an iron matte or copper-iron matte made by smelting pyrite or pyrrhotite ore, preferably containing gold and silver. This matte is readily decomposed by H_2SO_4, yielding H_2S. Ferrous sulphate also is formed and wasted. The residue contains the valuable metals, and is combined with the copper precipitated from the solution.

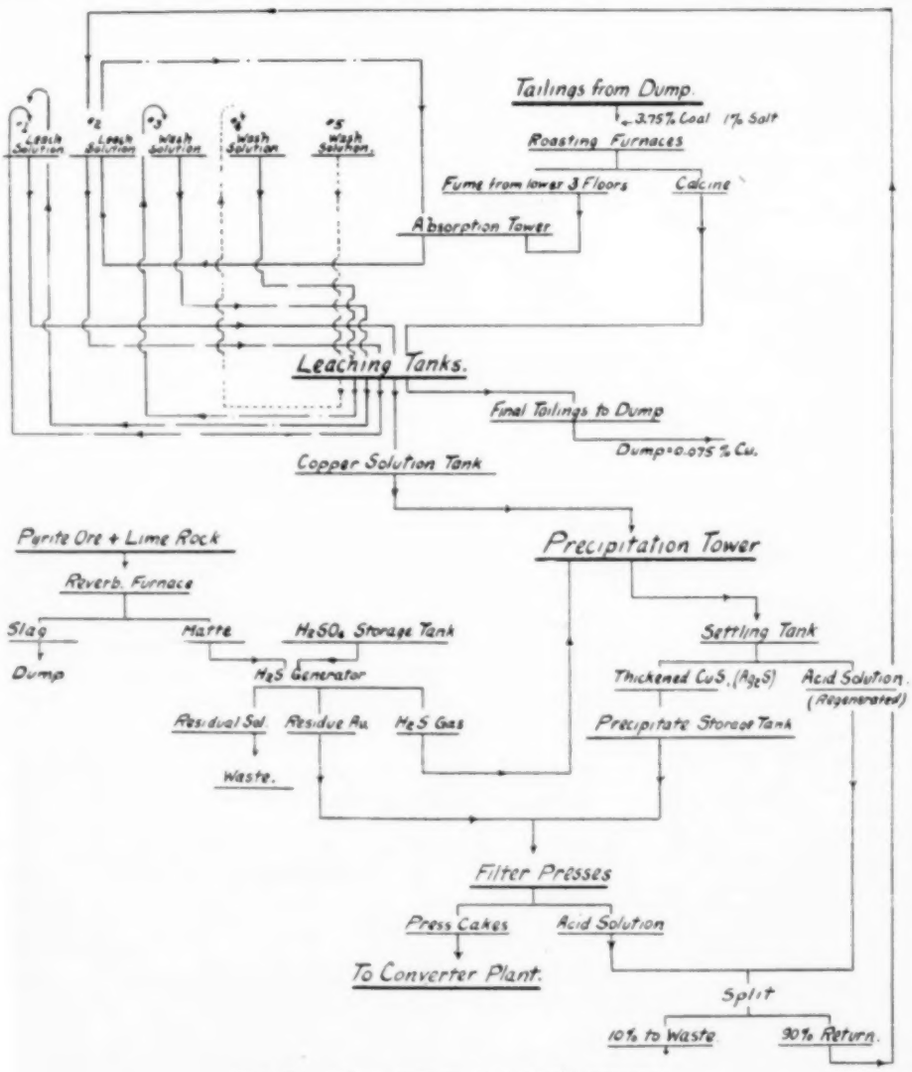


FIG. 1.—FLOW SHEET OF LAIST'S PROCESS

Two leach solutions and three wash solutions are shown in the flow-sheet. These are used in such a manner that the progressive increase in strength of the several wash solutions prevents an undesirable weakening of the leaching solution with which the wash solutions mingle. Various forms of apparatus may be used without affecting the process as long as the successive steps described are followed. (1,076,833, Oct. 28, 1913.)

Another hydrometallurgical process for copper, making use also of electrolysis, is that of Mr. HENRY S. MACKAY, of Riverside, Cal. The principal features of this process are (1) the preparation of the solvent ferric chloride, by electrolysis of sodium chloride with iron anodes; (2) the agitation of the ore with this solvent; and (3) the electrolytic deposition of the copper, with regeneration of the active solvent. (1,074,274, Sept. 30, 1913.)

The use of electrolytic iron as a precipitant of copper from solution is one of the features of a process patented by Mr. ALBERT DAVID, of Brooklyn, N. Y. The inventor leaches a copper ore with ferric chloride solution, precipitates the copper with electrolytic iron, and passes the impoverished solution to an electrolytic vat in which iron is removed for use as a precipitant. The solvent is regenerated in the process of electrolysis, and returned for further use. Certain auxiliary reagents are used to facilitate both the leaching and electrolysis. One of these is an alkali chloride; another is hydrochloric acid, and a third is a soluble sulphate such as sodium sulphate. If the original ore contains little or no soluble iron, the solution slowly becomes depleted of this metal, and some must be added from an outside source. If an excess of soluble iron is in the ore, some

of the metal must be discarded from time to time. (1,075,093, Oct. 7, 1913.)

Combination Smelting and Converting Furnaces.—In Fig. 2 is shown a longitudinal sectional view of a combination smelting and converting furnace for the treatment of copper ores, patented by Mr. Emil Knudsen, of Mühlbach, Austria-Hungary. The device is a tilting furnace in the form of a cylinder. At one end the bottom is provided with a recess 1, receiving blast pipes 2. This part of the furnace is of the Bessemer type. The part between the recess 1 and the opposite end 3 is constructed so that the bottom slopes toward the recess. There are two top openings, as shown, one being numbered 4 and the other 6. Number 6 is out of alignment radially with the opening 4, so that when the furnace is tilted molten material will escape through 4 without discharging anything through 6. In operation the ores charged through 6 are smelted and run onto the Bessemer recess 1, where copper is produced in the usual manner. (1,075,214, Oct. 7, 1913.)

Another form of furnace designed for similar purposes is shown in side elevation in Fig. 3, being the invention of Mr. George Mitchell, of Los Angeles, Cal. It consists of a smelting hearth 2 and a converter 3, the latter being located at one end of the furnace. At the

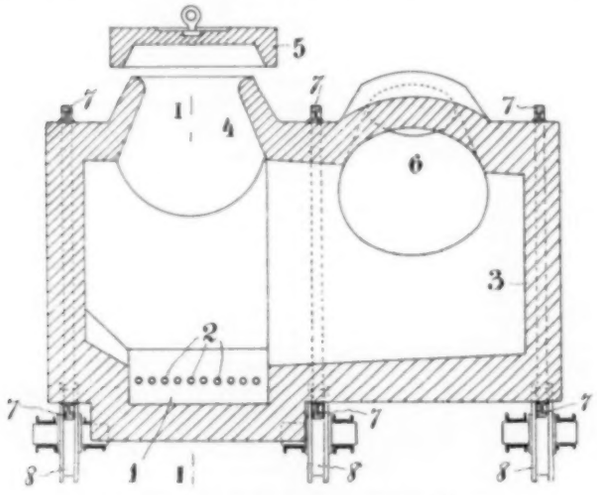


FIG. 2.—KNUDSEN COPPER FURNACE

opposite end is the stack and a steam boiler adjacent the stack if desired. Burners for oil or gas are located at 6. After smelting has progressed up to the point where there is sufficient matte to convert, the heat generated in that process will be of material assistance in carrying on the smelting operation. (1,074,282, Sept. 30, 1913.)

Zinc Smelting Under Pressure.—Various attempts have been made to smelt zinc ores in cupola furnaces, but have generally been unsuccessful. The vapor of metallic zinc has been reoxidized before it could be collected, and the fluxing materials have prevented precipitation. According to a patent granted to Mr. Elisha B. Cutten, of Erie, Pa., the inventor proposes to smelt zinc oxide free from gangue, and effect the reduction in a low blast furnace in a reducing atmosphere under pressure. Zinc oxide, produced by some suitable process, is briquetted with fuel, charged into a furnace heated by gaseous or liquid fuel, and smelted under a pressure of from 20 to 60 lb. per sq. in. The fuel is injected in such quantity as to produce reducing conditions. The furnace would be operated intermittently, and metallic zinc drawn at the end of the operation. (1,080,102, Dec. 2, 1913.)

Chloridizing Complex Ores.—A modification of the general proposal to chloridize complex sulphide ores by treatment with dry chlorine, is patented by Mr. Tormod R. Forland, of Broken Hill, N. S. W., Australia. The inventor has discovered that volatilized chlorides can be separated by fractional condensation, and he proposes subjecting the distilled chlorides to successively lower temperatures, thereby separating the metal salts. Thus,

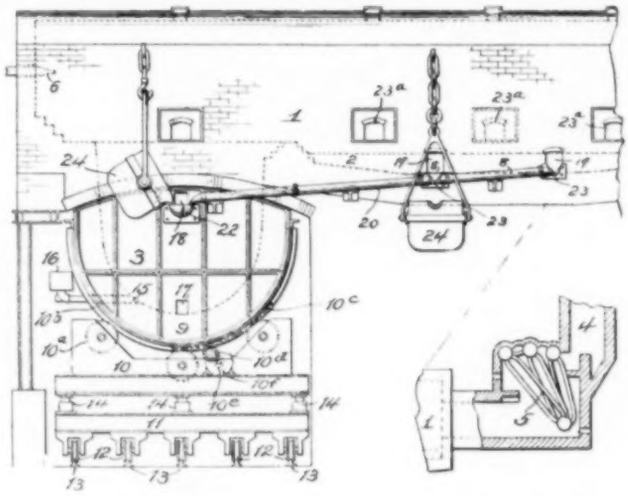


FIG. 3.—SMELTING AND CONVERTING FURNACE

lead chloride would condense at a temperature just under 900° C., zinc chloride just under 730°, etc. The fractions would be collected in a molten state or as sublimate in several condensers, and would be removed for electrolysis. The end products would be metals and chlorine, the latter being returned to the treatment for more ore. By varying the temperature of the distilling furnace, various fractions could be driven off and condensed. (1,078,779, Nov. 18, 1913.)

Metallurgical Furnaces.

Heating Furnace.—An improvement in furnaces of the type used for heating metal bars or rods, is shown in Figs. 4 and 5, being the invention of Mr. Walter S. Rockwell, of New York City. One object of the in-

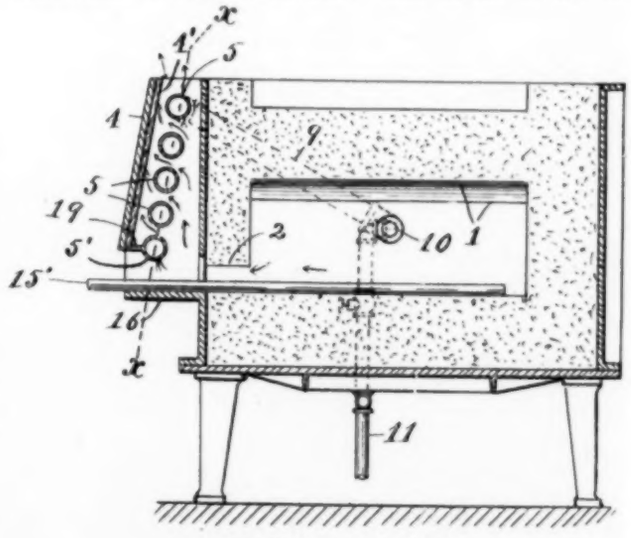


FIG. 4.—HEATING FURNACE

vention is to utilize the waste heat of the escaping gases to preheat the air used for combustion, and to construct this preheater in the form of a shield to protect the operator. The figures show a furnace with a heating chamber 1 and working opening 2. Heat is supplied through burners 10 on each side of the chamber, fuel being delivered to the burners through pipes 11. Air is

supplied to the burners through pipe 8, passing first through pipes 5 connected at their ends with headers 6, 7. A shield 4 is placed in front of pipes 5, and the entire arrangement of shield, headers and pipes forms a preheater for air and a protection to the operator. Hot air issues from the preheater through pipes 9 leading to the burners. (1,079,266, Nov. 18, 1913.)

Iron and Steel.

Reduction of Ores.—The specifications of a patent recently granted to MR. JAMES A. MCLARTY, of Toronto, Ontario, Canada, disclose the inventor's idea of reducing

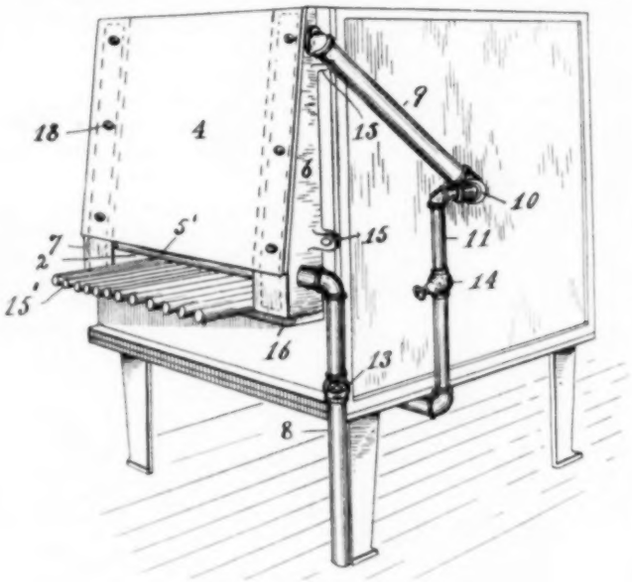


FIG. 5.—HEATING FURNACE

oxide ores by subjecting them to the action of reducing gases at a temperature below a red heat. In carrying out his process he supports the ore on a suitable grate above a bed of incandescent coke. Air is admitted freely to the coke fire, so that the product of combustion is practically all CO_2. At a point between the bed of fuel and the grate supporting the ore, he injects a spray of a liquid or gaseous hydrocarbon, or a finely powdered carbohydrate, or any other material that will reduce the CO_2 to CO and yield hydrogen. The temperature of the gas falls during this reaction, but is still high enough (750-800°F.) to permit reaction with the ore. The reaction takes place at a temperature above that at which sulphur and similar impurities will sublime from the ore, but below that at which sulphur or carbon will combine with the iron. Apparently the product of the reaction cannot be molten, and although the specification does not mention the physical condition of the product, it may be assumed to be "metallized" in solid form. (1,079,788, Nov. 25, 1913.)

Nodulizing Kiln.—A form of kiln for nodulizing iron ores, in which the formation of sintered rings of ore is said to be prevented, is the subject of a patent granted to MR. LEWIS P. ROSS, of Standish, N. Y. The kiln is of the usual rotary-tube type, inclined to assist the travel of ore from feed to discharge, and being fed with finely divided ore at the upper end and with a fuel flame at the lower. The point of distinction lies in the fact that the lower end of the kiln, about one-third of the total length, in which the adhesive rings of ore usually form, is separate from the upper portion, and whereas the upper portion rotates continuously, the lower part is merely oscillated, being actuated by a reversible motor. The result of the oscillatory action is that the adhesions of ore form in the shape of a crescent instead of a full circle. The thickest part of the adhesion being at the top of the kiln, the mass falls of its own weight and thus removes the obstruction. (1,076,705, Oct. 28, 1913.)

Gold and Silver.

Filter-Leaf and Method of Dislodging Cake.—In two patents granted to MR. CHARLES BUTTERS, of Oakland, Calif., the inventor suggests improvements in the construction of vacuum filter-leaves, and in the method of discharging the filter-cake from them.

The new form of filter-leaf consists of a rectangular frame of wooden members, in which shallow channels are formed on each face for receiving wooden strips by which the filter cloth is secured to the frame. The central pervious member of the filter is cocoa matting, and the outer filtering medium is drilling of light weight. In making the filter, a sheet of drilling is first attached to one side of the frame by means of the wooden strips inserted into the grooves or channels, and held in place by tacks or nails. Then the cocoa is laid in the frame, and the other filter cloth attached on the opposite side of the frame. Vertical strips of wood spaced at equal intervals along the opposite faces of the leaf are held in place by metal holders on the wooden frame, and are bolted together at their mid length. These serve to give rigidity to the leaf. The method of construction is simple, and avoids the necessity of stitching a filter bag in the usual manner. The leaf is easily demountable, and thin, relatively cheap filter cloth can be used, discarded and renewed at frequent intervals.

The improved method of dislodging the filter cake is apparently an effort to get away from the use of compressed air or liquid applied to the inner surface of the filter, in a direction reverse to that of filtration. Each filter leaf is provided with a header pipe, perforated on its under side with ¼-in. holes 3 in. apart, and supported well above the vacuum header. Through this perforated pipe water can be forced under pressure and caused to flow downward over the filter cake, thereby causing it to fall from the filter cloth. It is essential to the easy operation of this method that the filter cloth be smooth and that the cake be as dry as it is possible to make it by vacuum. In operation, after the cake has been formed and washed, it is suspended in air, and the full vacuum is applied for five or ten minutes. This will reduce moisture to about 20 per cent, and induce cracking of the cake. Thereupon the vacuum is cut off and water is applied through the header pipe mentioned. The cake is dislodged in from one to three minutes, and the filtering surface is thoroughly washed. (1,078,994, Nov. 18, 1913.)

Sterling Silver.—A new formula for sterling silver is patented by Mr. EDWARD D. GLEASON, of New York City. The feature of the formula is the use of boron to give hardness to the resulting alloy, and to remove occluded gases so that castings of the metal will be free from imperfections. The boron is first incorporated with copper, and then this mixture is added to silver. The inventor claims a sterling silver containing from .900 to .925 silver and from .75 to .100 copper and boron. (1,075,642, Oct. 14, 1913.)

Miscellaneous.

Production of Phosphoric Acid.—An improved method of extracting phosphoric acid from natural phosphates consists, according to specifications of patents granted to Mr. MAXIMILIAN M. HAFF, of Ottawa, Canada, in subjecting finely pulverized phosphate with clay to electric heat, and recovering the volatilized acid by fixing it with an alkali. The clay used is ordinary blue clay, and it is used in the ratio of 60 parts clay to 100 parts phosphate. The clay and phosphate form a fluid clag under the heat from the electric arc, and the acid is volatilized. No reducing action takes place, and is preferably prevented. (1,076,497-9, Oct. 21, 1913.)

Metallic Manganese from Ores.—MR. FRIEDRICH HEUSLER, of Dillenburg, Germany, has patented an improved method of extracting manganese from its ores. According to former methods of production, manganese ores were fluxed with lime and with reducing agents such as soot, oil or the like, and heated in a graphite crucible. The yield of manganese is low. The inventor has found that he can obtain a yield within 90 per cent of the theoretical by first calcining a part of the ore, thereby increasing the relative proportion of manganese, and then mixing some of the calcined ore with crude ore, fluxing and reducing as before. The proportions may be varied, but preferably are not below 20 per cent for the crude ore and not above 80 per cent for the calcined product. (1,078,199, Nov. 11, 1913.)

Solder for Aluminium.—A formula for aluminium solder, patented by Mr. CHARLES WILLMOTT, of Smethwick, England, consists of a mixture of 86 per cent tin and 14 per cent bismuth.

Production of Alkali Metals.—The decomposition of alkali cyanides for the production of sodium and potassium is patented by Mr. JOHN E. BUCHER, of Coventry, R. I. The inventor has discovered that if cyanides of sodium and potassium be heated with iron, or distilled through or in contact with incandescent iron, the cyanides are decomposed, yielding alkali metal and nitrogen. The carbon combines with the iron. (1,079,974, Dec. 2, 1913.)

Radiothorium.—Thorium minerals contain a radioactive substance, just as uranium minerals contain radium. In the process of manufacturing Welsbach mantels, a by-product known as meso-thorium is obtained. From this material a radioactive substance can be developed, known as radiothorium. Mr. LISE MEITNER, of Berlin, Germany, has patented an electrolytic process of producing radiothorium, consisting in the electrolysis of an acid solution resulting from the extraction of residues from the preparation of mesothorium. Radiothorium separates at the cathode in a relatively pure state. (1,076,141, Oct. 21, 1913.)

Recovery of Dust from Cement Kilns.—The dust escaping from cement kilns constitutes a loss of cement-making material, and is undesirable from many other points of view. The difficulty of collecting this dust arises from the high temperature of the gases, thereby eliminating the possible use of bags, as in smelter practice. Washers and the like introduce complications in the draft through the kilns, and have been unsatisfactory. Messrs. ROLLA C. CARPENTER, of Ithaca, N. N., and THOMAS J. FLEMING, of Los Angeles, Cal., have patented a process of producing draft in kilns and separating the dust from the waste gases. The dust collecting means consists of houses or structures composed of material having a high rate of heat conductivity and a large radiating surface. In these structures are hung numerous vertical wires or rods, forming a grill to intercept the dust particles. When the dust-laden gases are introduced into the structure, their velocity is greatly decreased, and the solid particles settle out by gravity. This general method has been used in smelting works with great advantage. In order not to interfere with the draft in the kilns, fans are placed between the kilns and the dust-houses. (1,078,254, Nov. 11, 1913.)

Transvaal Gold Production.—The number of companies reporting to the Transvaal Chamber of Mines in July, 1913, was 62. The quantity of ore milled during that period was 1,913,327 tons. There were 10,015 stamps in operation, with an average duty of 8.54 tons per 24 hours. Tube mills in commission numbered 287. The yield for the month was 655,389 fine ounces gold. The report shows the steadily increasing stamp duty due to the greater number of tube mills used.

Oxy-Acetylene Welding and Cutting

In connection with the recent New York convention of the American Society of Mechanical Engineers, the Davis-Bournonville Company gave on the afternoon of Dec. 4, to a large number of members of the society, a very interesting series of demonstrations and exhibitions illustrating the development in the oxy-acetylene and oxy-hydrogen processes of welding and cutting metals.

The program included demonstrations of acetylene generation, oxygen generation, welding and cutting torches, cutting steel risers and cutting rivet heads, welding boiler plates and tubes, cast-iron molding, aluminium, brass and copper welding.

A barrel welding machine was exhibited which attracted considerable attention, as did also the emergency equipment. The latter is a small complete outfit, handled easily by two men. The outfit is particularly useful in fire department work, train wrecks, etc. Six cuts were made through bars of iron about 1 in. square in less than two minutes. Among other features was the cutting of a piece of armor plate 16 in. thick with the oxy-hydrogen radiograph.

Laboratory Mill

We have received from Ernst Grunbach & Sohn in Freiberg, Saxony, Germany, a prospectus of a laboratory mill developed by this firm in conjunction with Dr. Th. Koerner.

As shown in the adjoining illustration, the frame of the mill proper is a cast-iron ring closed on both sides by circular plates, one of which is removable for the

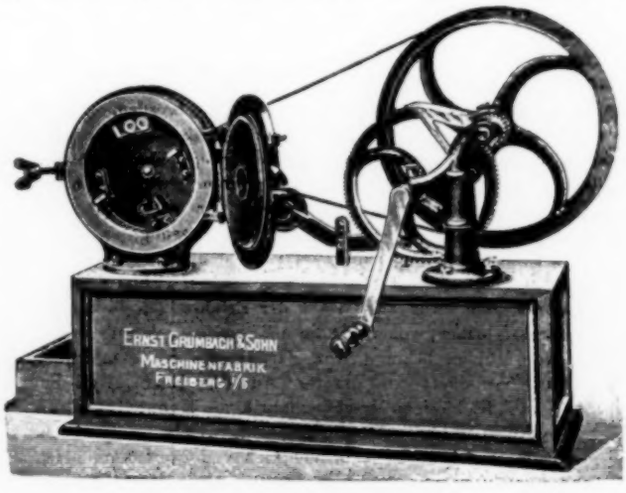


FIG. 1.—LABORATORY MILL

sake of inspection. The inner periphery of the ring is provided in its upper part with ribs, while a removable screen is placed at the bottom.

Within this ring a disk is revolving with a high speed, say, 3000 to 3500 revolutions per minute. The periphery of this disk has various projections which catch the material to be ground and throw it with great force against the ribs of the ring, whirling it around until it is disintegrated sufficiently to drop the screen in the bottom.

For cleaning, the mill is opened as shown in the illustrations and the revolving disk is taken out.

An essential element of satisfactory operation is a sufficiently high speed. This is most conveniently obtained by driving the mill with an electric motor.

The Bridgeport Testing Laboratories announce the removal of their office and industrial chemical laboratory to 388 John Street.

A New Electrolytic Process for the Production of Flat Perforated Copper Tubing for Radiators

The Electrolytic Products Company of New Jersey, manufacturers of automobiles and house radiators, condensers, tubing, etc., at 75 Clinton Street, Newark, N. J., have just put on the market articles made up of hollow perforated copper tubing produced by a novel and decidedly interesting electrolytic process of their manager, Mr. F. A. Feldkamp. (U. S. Patents 1,055,324, March 11, 1913, and 1,071,036 and 1,071,037, of August 26, 1913.)

Fig. 1 shows an automobile radiator made up of such flat perforated copper tubing and Fig. 2 shows samples of this tubing. The structure of this tubing will be best understood if we first describe merely the chief steps in its manufacture.

A flat lead strip, say of ⅛ in. thickness and perforated at intervals with ¼ in. holes staggered with reference to each other, is electroplated with copper, and the strip is then cut into suitable lengths. These are heated above the melting point of lead; the lead core is thereby melted out. What remains back is the copper plating in form of a light copper tubing of an internal contour corresponding to the original perforated lead strip.

Tubing of this structure is shown in Fig. 2. It is a

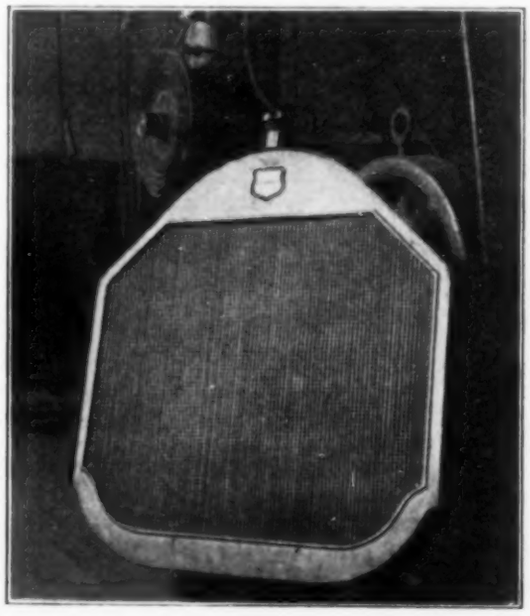


FIG. 1.—AUTOMOBILE RADIATOR

flat, hollow tubing, the distance between the two parallel flat surfaces being equal to the thickness of the former lead strip (⅛ in.). Where there were the holes in the lead strip, there are now little copper cylinders (diameter ¼ in.) holding the two flat sides of the copper tubing together. This method of construction greatly strengthens the tube against internal or external pressure.

The thickness of the copper walls of the tubing can, of course, be easily adjusted by extending or reducing the time of the electroplating operation. Tubes with walls 0.006 in. thick easily sustain a pressure of 15 lb. per square inch.

As far as the lead is concerned, this is used over and over again, and it may simply be stated that in practice no difficulty whatsoever has been experienced in removing the molten lead out of the copper plate structure. For this reason the process may be called the "plomb-perdu" process.

The chief interest of the process lies in the electroplating operation. This has been made continuous and automatic, the lead passing in form of a long strip through the plating bath. The time during which it is in the bath (or, what is the same, the speed with which the strip is passed through the bath) is so adjusted that a deposit of the desired thickness is obtained.

The plating bath has a length of 25 ft. One inch of tubing intended for automobile radiators leaves the bath every minute. For thinner tubing, such as used in aeroplane construction, 2 in. of tubing leave the bath every minute.

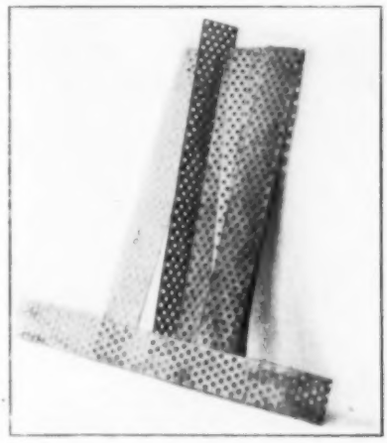


FIG. 2.—HOLLOW PERFORATED COPPER TUBING FOR RADIATOR

The chief striking feature of the process is in the anodes. These are in form of wires. The lead strip passes in vertical position and in horizontal direction through the plating bath. On each side of the lead strip there are a number of copper wires above each other, forming the anodes; they also pass in horizontal direction through the plating bath so that they enter the bath with a certain thickness and leave it with a smaller thickness. The wire strands travel through the electrolyte in the same direction of the band from one end of the bath to the other end and then back again.

The arrangement of the several wires is such that at the place of the heavy in-passing wires, there will also be thin out-passing wires. At any point across the series of moving wires within the electroplating tank, the reduction of the wires is such that the sum total of the cross-sectional areas of all the wires always remains the same. Thereby an absolutely uniform deposit from the wire anodes constantly moving through the electrolyte and out again is obtained.

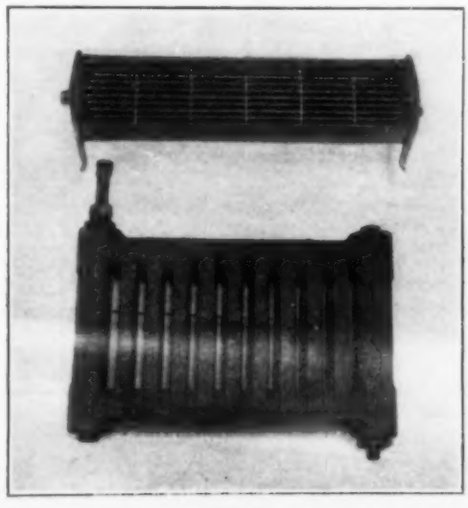


FIG. 3.—COPPER RADIATOR AND IRON RADIATOR FOR HOUSE HEATING

But the use of wire anodes has another important advantage. In the usual electroplating process there is always a loss of anodes in the form of scrap. This often amounts to 50 per cent of the weight of anodes. With this wire anode arrangement not only no anode scrap is produced, but the relative value of the wire is even in-

creased, because thin drawn copper wire is relatively more expensive than thick wire.

The practice of the company is to use wire of No. 8 B. & S. gauge as in-passing wire and let it leave the plating tank as No. 20 B. & S.

Tests of radiators made of this hollow perforated tubing show that they can be built to stand abuse and vibration on automobiles. As to the use of such radiators for ordinary house heating, their very compact form and light weight is a decisive advantage. Fig. 3 shows, for the sake of comparison, a copper radiator of this type and an ordinary iron radiation for house heating. The radiating surface of the copper radiator is 7.52 sq. ft., that of the iron radiator is 7 sq. ft., so that both are about the same. But the weight of the copper radiator is only 3 lb. 6 oz., that of the iron radiator is 48 lb.

Tests of condensers made of this hollow perforated tubing have shown that it is possible to build a condenser that will operate with 8.5 lb. of water per pound of steam, while usually 13 lb. of water per pound of steam is considered excellent and 20 not uncommon.

The manufacturers estimate that they can build a 100-hp condenser exclusive of air pump weighing 30 lb. for the condenser and probably not more than 100 lb. for the containing tank at a greatly reduced cost in comparison with usual constructions.

This tubing may also be used in the arts pertaining to apparatus and devices for electrical, chemical and electrochemical purposes.

While not embodying anything of a revolutionary character, the process is decidedly pretty in its conception and the details have been carefully worked out.

Laboratory Vacuum Cleaning

In many chemical laboratories a vacuum pump is available for various uses in connection with blow lamps, sand blast, agitation, testing, etc., and the object of this note is to describe the application of the vacuum pump to vacuum cleaning of the laboratory. This is a simple matter, as all that is required is the ordinary dust-separating tank, suitable lengths of pipe or hose, and the cleaning tools.

Fig. 1 shows an illustration of how a simple separating tank can be constructed. This is made of an ordinary 40-quart milk can which may be easily procured at the expense of a couple of dollars. The cover of this can forms an air-tight tank and, therefore, is especially adapted for this work. A round hole is cut in the cover and a pipe connection made as shown in detail in the sketch. The pipe or hose connecting the tank with the cleaning tool is attached at this connection.

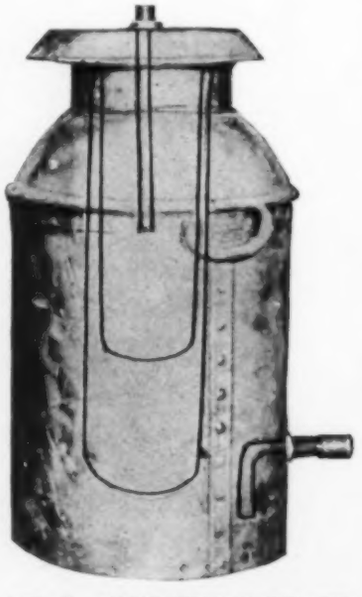


FIG. 1—SEPARATING TANK FOR VACUUM CLEANING

The connection from the can to the pump is made at the bottom in the same manner as above. This can is to act as a screen and to prevent the dust and dirt from entering the pump, and it, therefore, becomes necessary to provide a screen in the can to catch the dust and dirt. This is provided for by means of a bag made in suitable shape to set into the can about three-fourths of the way down, and made to rest over the neck of the can in such a manner that the cover will be drawn down over the top, holding it secure. This bag may be made of some suitable material such as canvas, canton flannel or suitable silk bolting cloth, depending on the amount of dust and dirt to be removed. The connection to the pump is made by means of pipe nipple and a union.

The machine is now ready for operation after attaching a belt to the pump from the motor or a line of shafting.

FIG. 2—VACUUM PUMP

If the dirt thus taken up contains valuable metals—and this happens often enough in laboratories—they are easily recovered in this manner.

Fig. 2 shows a vacuum pump made by Leiman Brothers, 62 John Street, New York City, specially for laboratory work. These pumps may be procured separately and the balance of the outfit assembled by anyone with any ordinary mechanical ability, or the entire outfits may be secured and the proper connections made. The pipe for blowing can be led from the pump to where the air blast is required and used as stated above for the various purposes in connection with the regular laboratory work.

Monel Metal

From Philadelphia comes the report of the consolidation of two of the oldest and most prominent hardware companies into a new corporation to be known as the Supplee-Biddle Hardware Company. The combining firms are the Biddle Hardware Company and the Supplee Hardware Company. The new concern is incorporated for $1,000,000, and will be the largest wholesale hardware distributing house along the Atlantic. Mr. Charles M. Biddle is the chairman of the board.

The corporation will occupy seven buildings, eight stories high and covering about six acres. One entire floor will be given up to Monel metal to the many uses of which the corporation will pay special attention.

As is well known, Monel metal is a "natural alloy" of metal and copper, produced by reduction from the Sudbury nickel-copper ores. It consists approximately of 68 per cent nickel and 30 per cent copper, the balance of 2 per cent being iron and manganese. It has a tensile strength of from 70,000 to 100,000 lb. per sq. in. —greater than bronze and equal to mild steel. It can be easily machined. But perhaps its most characteristic feature is its resistance to corrosion.

Wherever corrosion is a menace, Monel metal rods are proving their superiority over other metals. In pump rods, piston rods, shaftings, valve stems, machine bolts, etc., Monel metal outwears bronze rods by 50 to 100 per cent.

Monel metal pump rods are impervious to superheated steam, do not gather verdigris, and retain a smooth, glassy surface which reduces friction to a minimum and gives greater economy in power.

The Supplee-Biddle Hardware Company cite the experience of a coal-mining concern that placed an order for Monel metal special chute plates some time ago for use in loading gondola cars at their mines. As soon as these chutes were put into use they discovered that the smooth surface of Monel metal obviated the usual choking of coal and that better results and more even loading could be made at a greatly reduced angle of elevation or pitch. Moreover, experience appears to show that coal chutes of Monel metal will outlast steel coal chutes several times over.

To the manufacturer who has lost time and money

in a vain attempt to keep acid, salt pickle, tanning or chemical vats and tanks in condition with corrosion eating away his tie rods as fast as they can be replaced, Monel metal tie rods come as a great boon. Monel metal is being used for tie rods of all lengths and descriptions with great success.

Monel metal is also used for valve stems and wire cloth. Screen wire cloth of Monel metal, made by the Biddle Hardware Company, is used for window screening in the city of Colon at the Panama Canal operation. It is the only material the Government has found that will stand the climatic conditions of that territory.

For mines, railway work, chemical plants, sewage disposal plants and engineering operations where ordinary screens are quickly eaten away, Monel metal wire cloth gives splendid service. It has great tensile strength and railway or mine gases do not affect it.

One of the largest developments of the past year has been the successful forging of Monel metal up to 1000 and 2000 lb. Where bronze forgings are now used Monel metal forgings can be substituted. They have the advantage of being non-corrodible and in addition possess all the good qualities of bronze. Owing to the superior strength of Monel metal, lighter forging than bronze can be used unless a large size is essential. The cost of Monel metal forgings will average no more than bronze forgings, and in many cases the cost will be less.

Castings of Monel metal for many purposes have been made for some time, and the ability to make forgings of this metal is of great interest to the manufacturing world. For example, valve rings and seat disks and seat rings of castings are at the present time in extensive use. The Supplee-Biddle Hardware Company is now able to make forgings of disks and seat rings and also valve spindles by this method. In fact, many forgings of steel or bronze can now be duplicated in Monel metal.

Through the use of Monel metal corrugated gaskets the joint can be made as tight and as permanent as any other part of the line.

For use in exposed places where strength is essential and both flexibility and rust-resisting qualities are necessary, Monel metal ropes will give the maximum service and satisfaction.

Personal

Mr. **Luther B. Eames** has been appointed superintendent of the mill of the Goldfield Consolidated Mines Company, Goldfield, Nevada, and has assumed the duties of his position.

Mr. **H. N. Spicer** was married on November 17, 1913, to Mrs. Laura M. Stoiber. Mr. Spicer is in charge of the New York office of the Dorr Cyanide Machinery Company, and is residing at 12 Fifth Avenue, New York City.

Mr. **H. R. Conklin**, manager for the Lluvia de Oro Mining Company, Lluvia de Oro, Chihuahua, Mexico, was in Denver recently. He is spending some time in the States pending the settlement of troubles in Mexico, which have necessitated closing the property.

Mr. **B. B. Thayer**, president of the Anaconda Copper Mining Company, has been nominated for the presidency of the American Institute of Mining Engineers.

Mr. **Herbert Haas**, of San Francisco, has been appointed metallurgical engineer to the United States Bureau of Mines.

Mr. **C. C. Ferguson**, formerly with the Oliver Iron Mining Company, has been appointed consulting engineer to the Iron Mountain mine on the Cuyuna Range, Minnesota.

Mr. **Robert C. Sticht**, general manager for the Mount Lyell Mining and Railway Company, Tasmania, expects to make a tour of the world. He is expected to leave Australia this month.

Prof. **Robert H. Richards**, of Boston, was a witness in the recent litigation proceedings between the owners of Wilfley and Deister table patents, held at Indianapolis. Mr. **A. R. Wilfley** also was in attendance.

Mr. **Sidney J. Jennings**, vice-president in charge of exploration and mine investment for the United States Smelting, Refining and Mining Company, recently inspected the companies' Utah properties.

Mr. **George F. Waddell** has resigned his position as superintendent of the concentrator of the Steptoe Valley Smelting and Mining Company, McGill, Nevada, to become general manager for the Ohio Copper Company, Bingham and Lark, Utah.

Prof. **G. A. Roush**, of Lehigh University, has been appointed editor of *Mineral Industry*.

Mr. **Richard K. Meade**, consulting chemical, mechanical and industrial engineer, 202 N. Calvert Street, Baltimore, Md., has been retained by the Louisville Cement Co., to prepare plans for their new hydrated lime plant, at Mill Town, Ind. This plant will have a capacity of 60 tons of hydrate per day and be equipped throughout with the most approved appliances for the manufacture of hydrated lime. The plant will be located alongside of their new gas fired kilns on the opposite side of the river from their present hydrated lime plant.

Mr. **John Bellamy Taylor**, formerly with the General Electric Company, has opened offices as consulting electrical engineer at 23 Lowell Road, Schenectady, N. Y., and 100 Broadway, New York.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

REFINING METALS (*Continued*).

589,251, Aug. 31, 1897, John Oliver Surtees Elmore, of Kapurthala, India.

Relates to the refining of metals by electrolysis, and consists of a plurality of superimposed horizontal cells made by assembling a large cathode sheet, a wood frame resting on its edges, an anode of impure metal within the frame resting on the cathode, another cathode sheet, another frame and anode, etc., until as many as are wanted have been built up. The cathode sheets are perforated at one end within the frame, the perforations alternated in successive sheets. The assembled cells are suitably bolted together to prevent leakage. Electrolyte flows through the cells in a zigzag course and out of the bottom; it may be filtered when desired; it then flows into a "rocking trough" which empties first into one side, then into the other, of a large tank, and thereby serves to mix it; from the tank it is pumped to the top of the cells; the rocking-trough further serves to prevent a short-circuit. The current dissolves the anode and deposits the metal on the lower side of the cathode sheet above, the anode and cathode sheet constituting secondary electrodes.

589,252, Aug. 31, 1897, John Oliver Surtees Elmore, of Kapurthala, India.

Relates to the refining of metals, and consists of an apparatus constructed on the principle of that in his prior patent 589,251, except that the electrodes are vertical instead of horizontal; thereby forming vertical cells. The anode constitutes a secondary electrode, the electrolyte passing through in a zigzag course. The electrolyte passing out of the cell empties into a "rocking trough" as described in his prior patent.

592,097, Oct. 19, 1897, Bernard Moebius and Gustav Nebel, of New York, N. Y.; said Nebel assignor to said Moebius.

Relates to improvements in apparatus for carrying

out the process of electrolytic separation of silver described in U. S. patent 532,209, to Bernard Moebius. In said process it was found that the silver deposited tended to adhere to the belt, requiring scraping and resulting in injury to the belt. This tendency to adhere is overcome by continuously oiling the surface of the belt upon which the silver is to be deposited, which oiling efficiently prevents adhesion of the silver to the belt. The silver belt is also used to convey the deposit out of the tank, instead of transferring it to a separate conveying belt within the apparatus, as in the earlier patent.

593,837, Nov. 16, 1897, George E. Dunton, of Boston, Mass.

Relates to apparatus for continually circulating and thoroughly agitating all kinds of liquids, and especially adapted for electrolytic baths. Located within one corner of a tank is a centrifugal pump having an inlet strainer near the lower end of a suction pipe and an outlet pipe leading from the pump casing to the top of the tank on the opposite side at a point below the level of the liquid contained in the tank. The pump draws the heavy solution through the strainer from one corner at the bottom but without disturbing the sediment on the bottom of the tank, and discharges through an outlet on the opposite side near the top, causing the solution to take a circular motion around and between the anodes and cathodes.

614,633, Nov. 22, 1898, Friedrich A. Thum, of Newark, N. J.

Relates to apparatus for refining metals or extracting metals from ores, slimes, scrap metal, etc., the apparatus operating upon the series, or secondary, electrode principle. A series of racks are placed side by side within a tank at the ends of which are the principal anode and cathode. The racks consist of a frame having a set of spaced bars connecting the ends, and dividing the frame vertically into two halves, one of which is a receptacle for a raw-material container, and the other affording space for the electrolyte. The container consists of a box-like structure having a muslin bottom, which is placed in the frame with the muslin against and supported by the spaced bars. The container is now filled with the slimes or scrap metal, or ore, and against this is placed a metal or carbon plate held in grooves in the frame. The assembled frames are placed in the tank of electrolyte, and so connected that the scrap dissolves as anode and deposits upon the side of the metal or carbon plate of the next frame. The scrap, etc., may be replenished as desired through an opening in the frame.

617,526, Jan. 10, 1899, Elisha Emerson, of Buffalo, N. Y.

Relates to refining metals and depositing the metal as a tube, etc. The improvement is in the anode, which consists of supports of lead or other insoluble conductor, shaped so as to be concentric to the tube being deposited, and upon which (the lead supports) are secured the anodes of copper or other metal to be refined. The copper, etc., is in the shape of bars, which are held in lugs upon the lead supports.

617,886, Jan. 17, 1899, Elias A. Smith, of Anaconda, Mont.

Relates to purifying an impure electrolyte resulting from electro-refining crude copper. Such an electrolyte soon becomes so burdened with arsenic and antimony as to be unfit for further use. It is customary to evaporate it until sulphate crystals form, then run the mother liquid to waste. In the present invention, this mother liquid is still further concentrated in shallow lead pans until the iron salts present have crystallized out, and the specific gravity reaches about 55° Be. The liquor is then run out and cooled, a further deposit of copper sulphate crystals are then obtained, and the excess of liquor removed. To this excess liquor is added crystals of calcium or sodium thio-sulphate, which effect the precipitation of the arsenic and antimony and liberate a supply of sulphur dioxide which remains dissolved in the liquor, which is advantageous in the electrolyte by reducing the remaining iron to the ferrous state, and also retarding the oxidation of the arsenic to copper arsenate as the anode dissolves. After the removal of the arsenic, antimony and other precipitates, the electrolyte may be reused.

625,863, May 30, 1899, Emil Wohlwill, of Hamburg, Germany.

Relates to the refining of gold and gold alloys, using an electrolyte of gold chloride and hydrochloric acid. Prefers to use a solution containing 25 to 30 grams of gold per liter, and from 20 to 50 cubic centimeters of hydrochloric acid of specific gravity 1.19 per liter, at a temperature of from 60° to 70° C. Hydrochloric acid is added to replace that lost, and gold chloride is added periodically to keep a constant per cent in solution. The presence of platinum does not interfere; palladium in quantities of 5 drams per liter does not interfere. Silver accumulates on the anode as silver chloride and may be removed mechanically. In the presence of lead sulphuric acid may be added to the electrolyte to form lead sulphate, which should be removed from the anode. Bismuth may form a precipitate of oxychloride in the absence of sufficient acid. An anode 4 millimeters thick will be nearly consumed in twenty-four hours with a current density of 400 amperes per square meter. The deposited gold is pure.

Book Reviews

Zink und Cadmium, von R. G. Max Liebig. 16x23 cm., 598 pages (no index), 205 illustrations, 10 plates; price, bound, 32 marks. Leipzig: Otto Spamer.

At last, German technology has a treatise on the metallurgy of zinc. Professor Schnabel handled it well in his "Handbuch der Metallurgie," but a separate, exhaustive treatise was badly needed. Prof. Dr. F. Fischer, of Göttingen, needed this treatise as part of his collection of books on "Chemische Technologie," and asked the works manager, Max Liebig, to write it. The latter had been in zinc works for nearly a lifetime, and having retired found he had the leisure and the materials wherewith to write the book.

The work handles systematically, completely, and clearly every branch of the metallurgy of zinc. Electric zinc furnaces and electrolytically obtained zinc are satisfactorily written up; in fact, throughout the book, the completeness of the treatment is noticeable and commendable. If the very latest practice of zinc works is in some cases omitted, it is simply because the works refuse to allow it to be published. The *rationale* of the condensation of zinc vapor mixed with other gas is correctly explained on the principle of partial vapor tensions, but instead of this being credited to Roitzheim's publication in *Metallurgie*, in 1910, it should be credited to Richards' "Metallurgical Calculations," Part III, published in METALLURGICAL AND CHEMICAL ENGINEERING (often called Electrochemical and Metallurgical Industry), in 1908.

There are now three treatises on the metallurgy of zinc: that in English, by Ingalls is most complete on the side of American practice; that in French, by Lodin, is most complete on the side of Belgian practice; the German work of Liebig is the most comprehensive book of the three, and should be possessed by every one having any particular interest in any branch of the metallurgy of zinc.